Project: NISSAN LDM REDESIGN

Engineering change number: 10310226
Customer: Nissan
Filename: 10348029_SPE_000_AB_Rel_Nissan_LDM_Redesign_20160804.doc
Document name: Reliability Qualification Program
Document number: 10348029
Document version: AB
Document status: Valid
Number of pages: 62
Date: 04.08.2016

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Version history

Document version	Previous version	Date	Change description (including number)
1.0		22.01.2016	First draft
2.0	1.0	01.02.2016	Ch. 05. Test Flow Plan: test flow updated to version from 29.01.2016. Ch. 4 VI/07 Random Vibration Endurance Test: test parameters changed (test duration per axis to 56.7 h and calculation remark added). Ch. 9 MS/11 Terminal strength test: introduced as new and all subsequent chapters re-numbered.
3.0	2.0	08.02.2016	Ch. 09. L2 drawing with & without shield inserted. Ch. 23. CH/12 Corrosive atmosphere test removed. Ch. 05. Test Flow Plan: test flow updated to version from 02.02.2016. Ch. 04 Customer standards mentioned with edition number.
4.0	3.0	10.02.2016	Ch. 03. Deviation inserted: Dwell will be performed only on the axis where the resonance frequency was found. Ch. 15. Operation mode for switched OFF mode inserted. Ch. 22. Operation mode for IGN OFF mode inserted. Ch. 21. Cross section remark inserted according project team.
5.0	4.0	10.02.2016	Ch. 21. Cross section remark updated according project team.
6.0	5.0	01.03.2016	Ch.05. Test Flow Plan: test flow updated to version from 25.02.2016 Ch. 23. Inserted new ch. LT/02 Constant humid heat life test Ch.24. CH/12 Corrosive atmosphere test re-inserted. Ch21&ch22 Acceptance criteria updated according project team agreement. First page- project responsible changed.
7.0	6.0	07.03.2016	Ch.22 LT/03: Thermal Life Test, new t1, t2 and N cycles values updated according values provided by project team. Additional notes for IGN on changed. ΔTeq hypothetic value considered. Ch.21 LT/01 ΔTeq hypothetic value considered.
8.0	7.0	16.03.2016	ECN number inserted Ch.22 LT/03 mission profile inserted. Ch.23 LT/02 mission profile inserted. Ch.04 Internal specifications, Parametric test Instructions.docx added. Ch.05. Test Flow Plan: test flow updated to version from 25.02.2016 with changed name.
9.0	8.0	01.04.2016 04.04.2016	First page: Document number from SAP added . Ch.05. Test Flow Plan: test flow updated to version from 17.03.2016. Ch.04 Internal specifications, Renault RSA 15 LCU LDM - LTT Specifications.docx added. First page: Document number from SAP changed.
10	9.0	08.04.2016	Ch.8 MS/07 Shocks from the road test value for duration D corrected to 11ms. Ch.22 LT/03 mission profile for L3 variant inserted. Ch.23 LT/02 mission profile for L3 variant inserted.
11	10	21.04.2016	Ch.21 LT/01: Thermal Cycling Life Test, Test parameters updated. Drawing for cross-section investigation inserted.
12	11	21.04.2016	Ch.21 LT/01: Thermal Cycling Life Test, Deviation inserted for stabilization td=10 min. Ch.2 VI/01 Resonance Point Detecting, Drawings with critical points added.

13	12	25.04.2016	Ch. 21 LT/01: Thermal Cycling Life Test, Remark provided by project team inserted. . Drawings for measurement points & Thermal picture provided by project team inserted. Ch. 20 LT/00: Self Heating Temperature Measurement ,Remark for measurement points added. Drawings for measurement points & Thermal picture provided by project team inserted. Editorial changes;Page numbering updated. Test Flow attached as pdf.
14	13	26.02.2016	Ch.05. Test Flow Plan: test flow updated to version from 08.04.2016
15	14	12.05.2016	Ch. 21 LT/01: Thermal Cycling Life Test, New cross section drawing and measuring points inserted (provided by project team). Ch.05. Test Flow Plan: test flow updated to version from 29.04.2016 Ch. 15 CL/07 Temperature range step test, operating mode remark added for clarification.
AB	15	04.08.2016	Editorial changes: New ECN inserted. Document released. Document version AB. Checker list updated.

Contents list **Page**

0 Generals

0.1 Purpose

The purpose of this document is to describe the environmental qualification program that must be successfully completed in order for Continental and the customer to consider the assembly qualified for use in the end application for which it was designed. This specification was developed in accordance with the customer environmental test specifications and international standardization.

0.2 General Test Conditions

All DUTs have to be clearly marked by the development department.
Use of original connectors and cable harnesses is obligatory.
All deviations need to be mentioned in the test order.
Use of new cable harness is recommended.
Vehicle mounting position: Engine compartment

Unless otherwise specified, all tests shall be performed at:

Standard atmospheric conditions for measurement and tests (acc. 28401NDS01 [10], chapter 8.1.1)	
Relative Humidity	60%± 15 %
Air Pressure	96kPa± 10kPa
General Definitions	
Room Temperature (RT)	(23 ±5)°C
Power Supply (U_{nom}) for 12[V] system	(13.5±0.5) V
Minimum Power Supply (U_{min}) for 12[V] system	9V
Nominal Power Supply (U_{nom}) for 12[V] system	13.5V
Maximum Power Supply (U_{max}) for 12[V] system	16V
Temperature Reference Point	Ambient Temperature/Chamber Temperature
Thermal Stability	State when the temperature of all parts of the EUT are within 3 °C, or as otherwise described by the relevant specification of the final temperature (acc. IEC 60068-1)
Supply voltage (U_A) (engine/alternator operative)	(13.5±0,5) V
Supply voltage (U_B) (battery voltage)	(12±0,5) V

Unless otherwise specified, the variables used shall have the following tolerances:

- ± 5% for the specified voltages, currents and fields.
- ± 10% for time slots, distances, energies and powers.
- ± 10% for capacitors, resistors, inductances and impedances.
- ± 2°C for temperatures

0.3 Glossary

EUT	Equipment Under Test
DUT	Device Under Test
DV	Design Validation
PSD	Power Spectral Density
PV	Product Validation
RH	Relative Humidity
RMS	Root Mean Square
RT	Room Temperature
t	Time
T	Temperature
TF	Test Flow
QP	Qualification Program
LDM	Led Driver Module

0.4 Referenced Standards and Documents

Internal Specifications	Parametric test Instructions.docx 2016-03-01	Parametric Tests Project RSA_LDM
	Renault RSA 15 LCU LDM - LTT Specifications.docx 2014-11-03	Life Time Test System Specifications
Customer	28401NDS01_10 2012-03 Rev 10	NISSAN DESIGN SPECIFICATION
	28401NDS01[1] 3-2-1 2002-03	NISSAN DESIGN SPECIFICATION
	28400NDS00 [7] 2004-03	NISSAN DESIGN SPECIFICATION
International Standards	ISO 16750-4 2010_04	Road vehicles — Environmental conditions and testing for electrical and electronic equipment
	IEC 60068-2-1 2007-03	Environmental Testing; Part 2: Tests; Test group A: Cold
	IEC 60068-2-2 2007-07	Environmental Testing Procedures; Part 2: Tests; Test B: Dry heat
	IEC 60068-2-6 2007-12	Environmental Testing; Part 2: Tests; Test FC: Vibration (sinusoidal)
	IEC 60068-2-14 2009-01	Basic Environmental Testing Procedures; Part 2: Tests; Test N: Change of temperature
	IEC 60068-2-27 2008-02	Environmental Testing; Part 2-27: Tests; Test Ea and guidance: Shock
	IEC 60068-2-29 1987	Basic Environmental Testing Procedures;Part 2: Tests; Test Eb and guidance: Bump
	IEC 60068-2-32 1975 Withdrawn edition	Basic Environmental Testing Procedures ; Part 2: Tests; Test Ed: Free fall
	IEC 60068-2-38 2009-01	Basic Environmental Testing Procedures; Part 2: Tests; Test Z/AD: Composite temperature/humidity, cyclic test
	IEC 60068-2-60 1995-12	Environmental Testing Procedures; Part 2: Tests -Test Ke: Flowing mixed gas corrosion test
	IEC 60068-2-64 2008-04	Environmental Testing; Part 2-64: Test Fh: Vibration, broadband random and guidance

0.5 Test Flow Plan

- **Test Flow Plan for DV qualification:** LDM_DV_Flow_Chart_Nissan_new_design_April29_ 2016.pdf

0.6 Operation Modes, Monitoring Criteria

Operation Mode	Electrical State
Operation Mode 1: No voltage is supplied to the DUT	
1.1	not connected to a power supply system
1.2	connected according to the vehicle installation, but no voltage applied
Operation Mode 2: The DUT is electrically operated with supply battery voltage (12V ± 0,5V) as in a vehicle with shut-off engine and with all electrical connections made.	
2.1	System/component functions are not activated (e.g. sleep mode)
2.2	System/component with electrical operation and control in typical operating mode
Operation Mode 3: The DUT is electrically operated with supply engine/alternator operative voltage (13,5V ± 0,5V) and with all electrical connections made.	
3.1	System/component functions are not activated.
3.2	Systems/components with electric operation and control in typical operating mode.

Monitoring criteria for the environmental test:

If monitoring is required, a periodic, intermittent or continuous monitoring of the DUT during the environmental test shall be done as described in the test procedure or the Specification for the Life Time “Renault RSA 15 LCU LDM - LTT Specifications.docx”.
All pertinent performance characteristics shall be measured, recorded and compared to the product performance limit defined in the Product Functional Test Specification: “Parametric test Instructions.docx”.
Functions and parameters to be monitored during or after an environmental test shall be defined by the project team in accordance with the vehicle manufacturer's specification.
Any performance limit identified outside the tolerance limit shall be considered a failure and shall be fully documented.

0.7 Operation Classes definition:

The minimum functional status shall be given for each test. Vehicle manufacturer and Continental shall specify operations that are not allowed.

Class A	All equipment/system functions are fulfilled normally (100 % functional) during and after the constraint.
Class A' (*)	All equipment/system functions are fulfilled normally (100 % functional) after the constraint (this class only concerns equipment whose operational check is not required during the tests).
Class B	All equipment/system functions are fulfilled normally during application of the constraint; however, one or several of them may be out of the specified tolerances. After application of the constraint, all functions automatically return within standard limits. The memories shall remain in compliance with Class A.
Class C	One equipment/system function is not fulfilled normally during application of the constraint but automatically returns within normal limits on completion.
Class D	One equipment/system function is not fulfilled normally during application of the constraint and does not automatically return within standard limits on completion, and the equipment/system is re-initialized through a simple action on the part of the user.
Class E	One or several equipment/system function(s) is (are) not fulfilled normally during and after application of the constraint and it is impossible to restore correct operation without repairing or replacing the equipment/system.

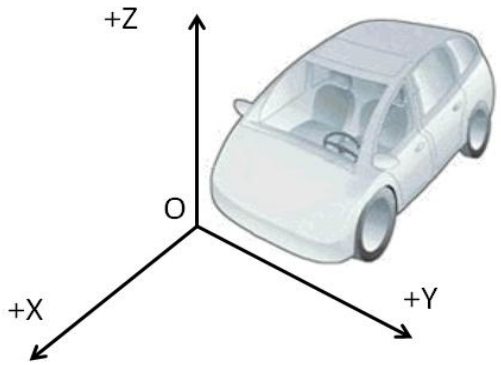
0.8 Classification of Gravity Level:

Level	Effects	Definitions
0	No	
1	Minor	Negligible damage and without risks for man and the environment
2	Major	Without important damage or major risk for man and the environment

The system or equipment shall be designed so that no electromagnetic disturbance can be the cause of a catastrophic effect.

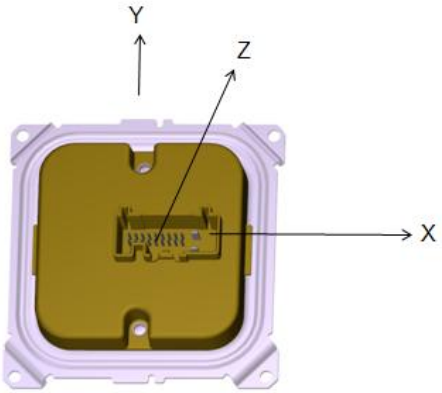
0.9 Drawing

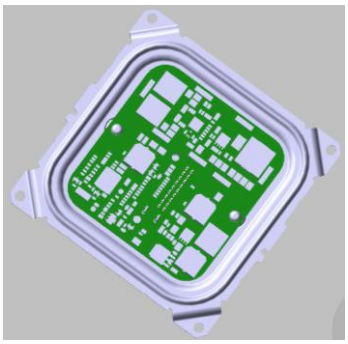
Car axis:

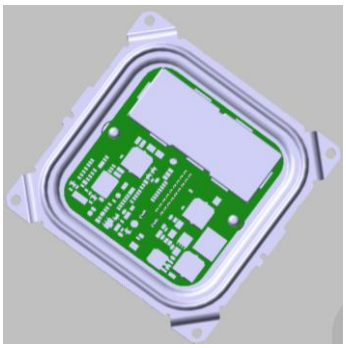


NISSAN LDM REDESIGN axis:

Connector on + Z axis




Without shield


With shield

1 Parametric Tests

1.1 Initial and final performance test

Electrical Parameters:
-ECU is tested at three temperatures (RT- Room temperature (23 ±5)°C, LT- low temperature(-40 °C) and HT- high temperature(+105 °C)) and at three supply voltage values.

Mechanical Parameters:
- Check samples for deformation (bending of the housing, twist of the housing and dents in the housings);
- Check housings for damages like scratches, cracks and color changes;
- Shake samples to check for loose parts inside the housing;
- Check label on the housing (prints and adhesion);
- Check connector pins, latches of plastic lid.

Visual Inspection:
Before and after all test sequences a visual inspection of the DUT shall be performed.

For more details, see “Parametric test Instructions.docx”.

1.2 Functional test

Electrical Parameters
The Functional tests are done only at RT and nominal supply

Mechanical Parameters:
- Check samples for deformation (bending of the housing, twist of the housing and dents in the housings);
- Check housings for damages like scratches, cracks and color changes;
- Shake samples to check for loose parts inside the housing;
- Check label on the housing (prints and adhesion);
- Check connector pins, latches of plastic lid.

For more details, see “Parametric test Instructions.docx”.

2 VI/01 Resonance Point Detecting test (Resonance Investigation)

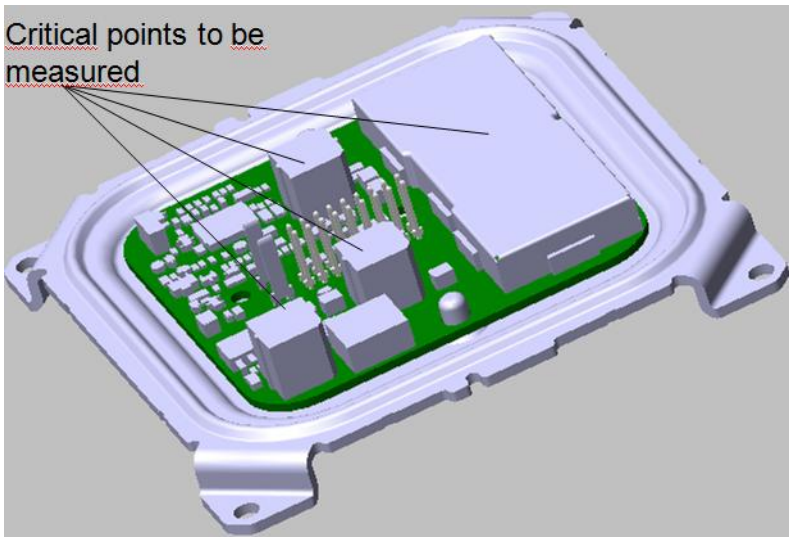
Reference: 28401NDS01 [10]

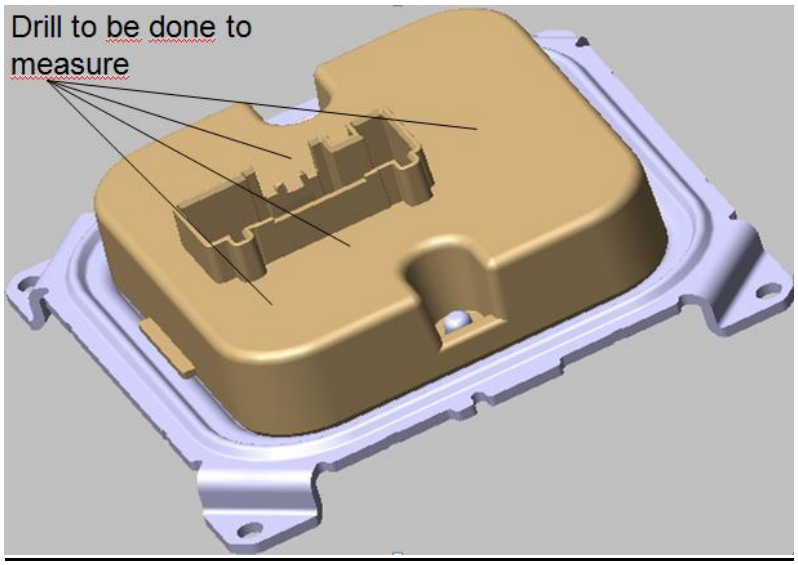
Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: 28400NDS00 [7]

Test parameter:

EUT number	2
Acceleration:	9,8 m/s^2
Temperature:	R.T.
Frequency range	10-1000 Hz
Sweep rate increase/decrease:	1Hz/s (linear sweeping)
Total test time:	33 min.
Critical points (where accelerometers should be placed)	see drawing below
Cycle:	10Hz -> 1000Hz -> 10 Hz
Maximum amplitude:	20mm
Operation mode:	3.2
Operating class:	A
Gravity Level	0





Initial evaluation of test:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT.

Test procedure:

A. Fix the EUT to the shaking table directly, or with a fixing jig, in the similar attitude to the actually-fixed state
B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 ± 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

3 VI/05 Resonance Point 1h Oscillation test

Reference: 28401NDS01_10

Deviation:- the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.
- dwell will be performed only on the axis where the resonance frequency was found.

Applicable standards: IEC 60068-2-6 Fc : Sinusoidal vibrations

Test parameter:

EUT number	2
Acceleration:	29,43 m/s^2
Temperature:	R.T.
Test frequency:	Resonance points are detected with test §2. If there are, one or more resonance point(s) test at each of the found resonance frequencies. If there is no resonance point detected: Perform no test
Test duration (each axis):	1 h
Operation mode:	3.2
Operating class:	A
Gravity Level	0

Initial evaluation of test:
Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT.

Test Procedure:
A. Fix the EUT to the shaking table directly, or with a fixing jig, in the similar attitude to the actually-fixed state
B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 ± 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.
All parts and materials constituting electronic equipment must be functional without any permanent deformation of the fasteners, mechanical damage such as deformation or cracks (elements, circuit board (including soldered areas), connectors and aluminum parts).

4 VI/07 Random Vibration Endurance Test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Deviation: Test duration per axis 56.7h, agreed with customer.

Applicable Standard: IEC 60068-2-64 Fh : Vibration, broad-band random (digital control) and guidance

Initial evaluation of test:
Based on the specified product standard, conduct a visual inspection, electrical performance inspection and mechanical performance inspection of the EUT.

Test parameters:

EUT number	6
Testing duration/ axis	56.7 h/ each axis
Warranted mileage (in kilometers)	100000[km]
Product destination	All destinations
ECU mounting location code	III (body side in engine compartment)
Minimum test temperature Tmin	-40 °C
Maximum test temperature Tmax	+85 °C
Rate of air temperature change	2°C/min max
Operation/Monitoring Mode	3.2
Operating Classes	Class A
Operating Level	0

Remark: According Nissan explanations:

1. According to VI/07 table 3, EUT Number=6, warranted mileage=100000km, testing duration/ axis= 7.5 h/ axis.

2. For C-grade parts, according Nissan the warranted mileage=120000km, so testing duration/ axis=7.5*1.2=9 h/ axis.

3. LDM is not only used in PV car but also used in R&CV, and take into consideration the road load durability and the destinations, we need to take the factor 6.3 of 9 h/axis. So, testing duration/ axis=9*6.3=56.7 h/ axis.

If the number of ECU is more than 6, the testing duration can be shorted.
If you use N=9 for VI/07, the testing duration=7*1.2*6.3=53 hours/axis.

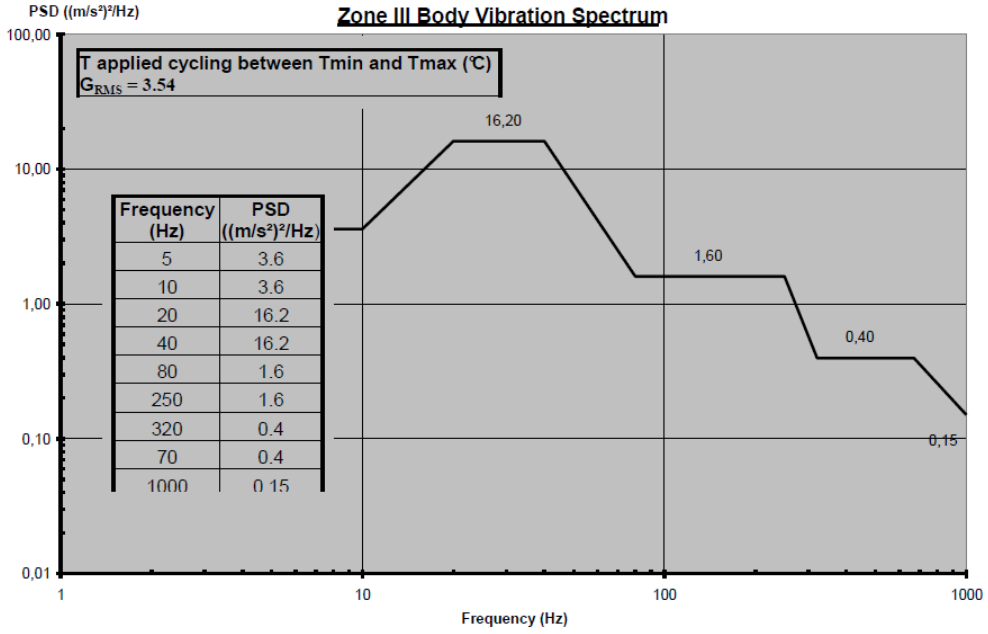
Initial Evaluation of Test:

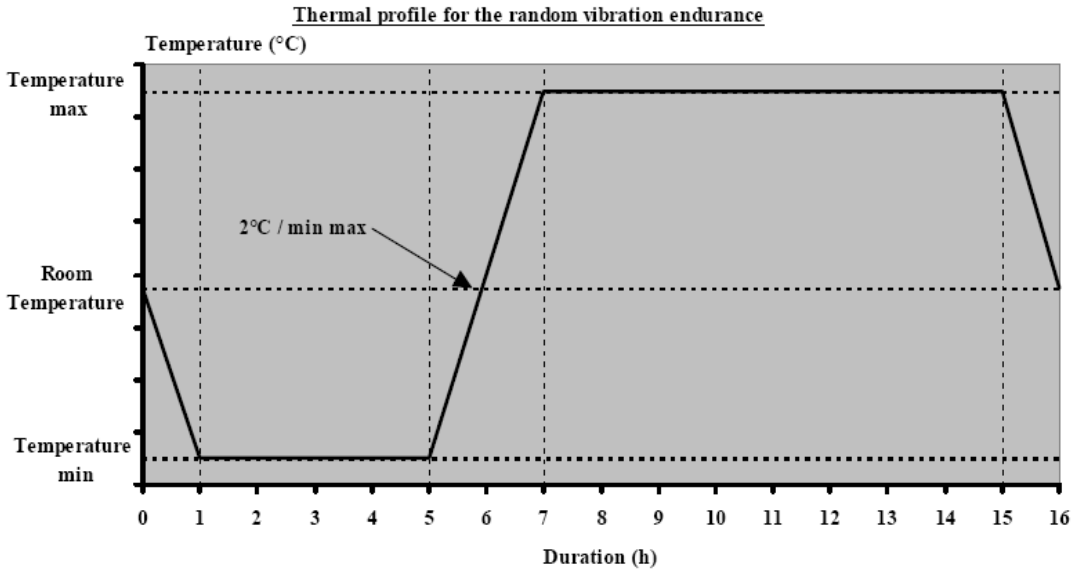
Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Fix the EUT with the nominal tightening torque to the shaking table with its vehicle fixture directly in the similar position to the actually-fixed vehicle state. In case of several vehicle fixtures or if the vehicle fixture is not designed yet, the test may be performed with the EUT directly fixed to the shaking table or with a fixing jig in the similar position to the actually-fixed vehicle state. Each vehicle fixture will have to be designed to be stiff and not create resonance oscillation in the frequency bandwidth (5-1000Hz)

B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 ± 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.
E. During the test, connect the electrical load equivalent to the actual one to the EUT, and apply the power
F. In the case of a duration of test different from 16h, the supplier needs to adjust the thermal profile trying to keep the ratio between Tmin and Tmax and the duration of test.





Thermal profile calculated for 56.7 h:

Duration: 56.7 h/axis => 3 cycles of 18.9 h each.

One Thermal Cycle of 18.9 h:

- 4.72 h at Tmin
- 9.45 h at Tmax
- 4.72 h for temperature slopes

Recovery after test:

After completion of environmental test ECUs shall remain in standard atmospheric conditions for a period adequate for the attainment of temperature stability

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

There shall be no permanent deformation of the fasteners, no mechanical damage such as deformation or cracks.

5 MS/01 Free Fall test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: IEC 60068-2-32 Ed (withdrawn edition)

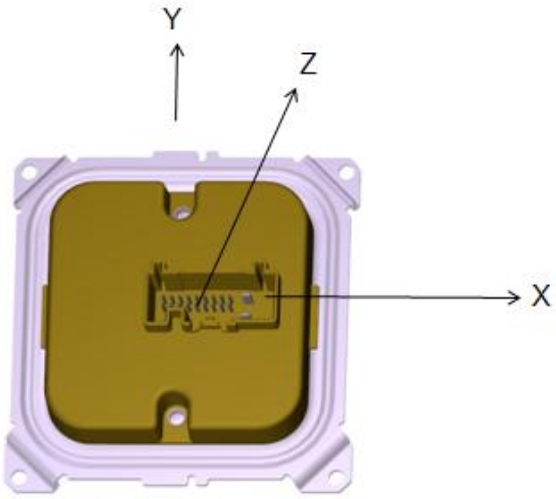
Test Parameters:

EUT number	6
Drop Height	1 m
Impact Surface	Concrete ground
Test Temperature (T)	RT
Temperature Reference Point	Ambient temperature (laboratory temperature)
DUT Test Position	See drop directions and numbers below
Operation/Monitoring Mode	1.1
Operating Class	A'
Gravity Level	0

Drop Directions and Numbers:

DUT	Drop directions	
	1st drop	2nd drop
A	+X	-X
B	+Y	-Y
C	+Z	-Z

Drawing:



Initial Evaluation of Test:

Conduct a visual inspection, electrical performance inspection and mechanical performance inspection of the EUT.

Test Procedure:

A. The DUTs are to be dropped according the parameters given above.
B. Visually inspect the DUTs for any obvious damage visible to the naked eye. Any and all damage noted following each drop must be fully documented with pictures, clearly noting the axis in which the damage occurred (refer to the definition of axes section).

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

The product engineer has to have plant workers handle the electronic product properly not to be used in case the electronic product dropped even if the ECU is not visibly damaged. Renault/Nissan's recommendation is to affix a label "TO THROW AWAY IN CASE OF FREE-FALL" on the electronic product. In the case where there is no place for a label, other possibilities are tolerated, like stamps or an inscription directly in the mold of the housing.

6 MS/02 Mounting operation shock test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable Standard: IEC 60068-2-27 Ea

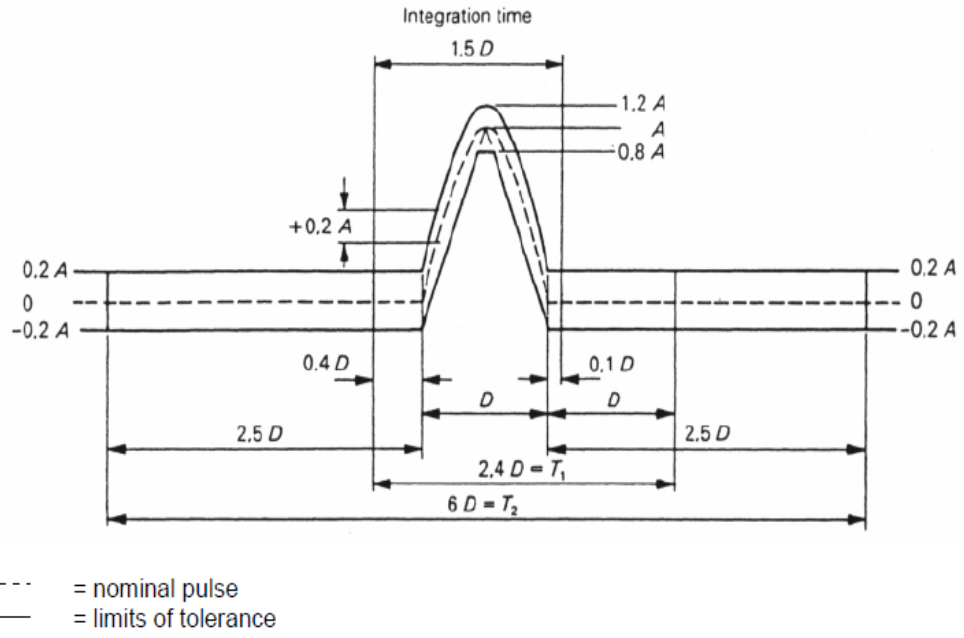
Test Parameters:

EUT number	6
Shock Form (Pulse Shapes)	Half-sinusoidal
Number of shock per direction	3
ECU direction to test	X-, X+, Y-, Y+, Z-, Z+
Number of shocks cumulated per ECU	18
Peak acceleration of nominal pulse	A = 1000 m/s^2
Duration of nominal pulse	D = 6 ms
Test temperature	R.T.
Operation/Monitoring Mode	1.1
Operating Classes	Class A'
Operating Level	0

Temperature and Number of Shocks per Direction

Temperature	Mechanical Shocks Each Direction					
	+X	-X	+Y	-Y	+Z	-Z
RT	3	3	3	3	3	3

MS/02 to MS/05 Figure 1: Half-sine wave test profile.



D = duration of nominal pulse
A = peak acceleration of nominal pulse
T1 = minimum time during which the pulse shall be monitored for shocks produced using a conventional shock testing machine
T2 = minimum time during which the pulse shall be monitored for shocks produced using a vibration generator

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Fix the EUT to the shaking table directly, or with a fixing jig, in the similar attitude to the actually-fixed state
B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 ± 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.
E. Place the vibration control on the vibration fixture, the closest to the DUT.
F. Perform 3 successive shocks in each axis (X-, X+, Y-, Y+, Z-, Z+) as defined above.
G. 18 shocks in total per DUT

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

7 MS/03 Collision Impact

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable Standard: IEC 60068-2-27 Ea

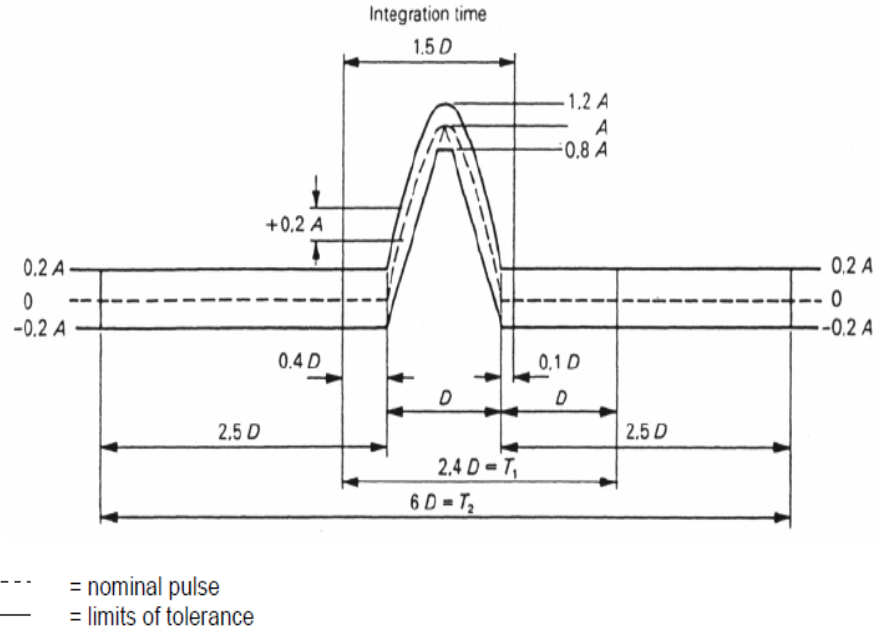
Test Parameters:

EUT number	6
Shock Form (Pulse Shapes)	Half-sinusoidal
Number of shock per direction	1
ECU direction to test	X-, X+, Y-, Y+, Z-, Z+
Number of shocks cumulated per ECU	6
Peak acceleration of nominal pulse	A = 400 m/s^2
Duration of nominal pulse	D = 11 ms
Test temperature	Room temperature
Operation/Monitoring Mode	3.2
Operating Classes	Class A
Operating Level	0

Temperature and Number of Shocks per Direction

Temperature	Mechanical Shocks Each Direction					
	+X	-X	+Y	-Y	+Z	-Z
RT	1	1	1	1	1	1

MS/02 to MS/05 Figure 1: Half-sine wave test profile.



D = duration of nominal pulse
A = peak acceleration of nominal pulse
T1 = minimum time during which the pulse shall be monitored for shocks produced using a conventional shock testing machine
T2 = minimum time during which the pulse shall be monitored for shocks produced using a vibration generator

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Fix the EUT to the shaking table directly, or with a fixing jig, in the similar attitude to the actually-fixed state
B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 $\pm$ 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.
E. Place the vibration control on the vibration fixture, the closest to the DUT.
F. Perform 1 successive shock in each axis (X-, X+, Y-, Y+, Z-, Z+) as defined above.
G. 6 shocks in total per DUT

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

8 MS/07 Shocks from the road test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable Standard: IEC 60068-2-29 Eb

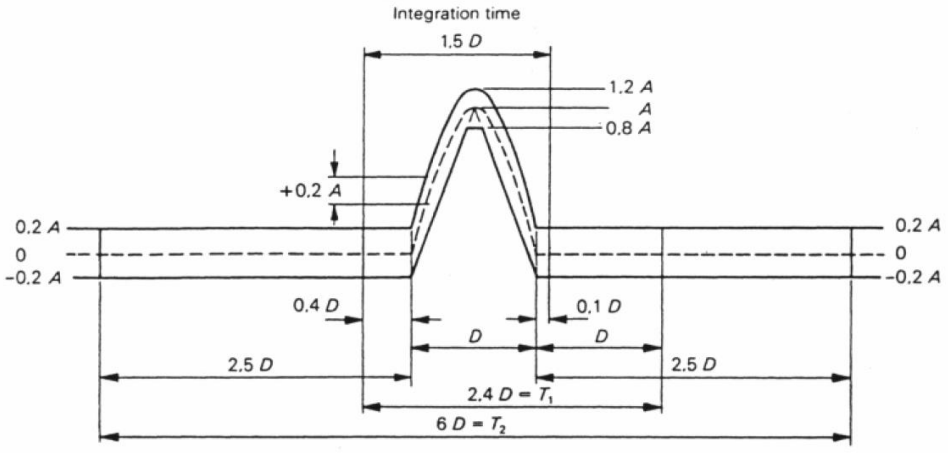
Test Parameters:

EUT number	6
Shock Form (Pulse Shapes)	Half-sinusoidal
Number of shock per direction	1
ECU direction to test	X, Y, Z
Number of shocks cumulated per ECU	6
Peak acceleration of nominal pulse	A = 400 m/s^2
Duration of nominal pulse	D = 11 ms
Test temperature	Room temperature
Operation/Monitoring Mode	3.2
Operating Classes	Class A
Operating Level	0

Temperature and Number of Shocks per Direction

	Mechanical Shocks Each Direction					
Temperature	**+X**	**-X**	**+Y**	**-Y**	**+Z**	**-Z**
RT	1	1	1	1	1	1

MS/07 Figure 1 : Half –sine wave test profile.



---------- = nominal pulse
_____ = limits of tolerance

D = duration of nominal pulse
A = peak acceleration of nominal pulse

T1 = minimum time during which the pulse shall be monitored for shocks produced using a conventional shock testing machine

T2 = minimum time during which the pulse shall be monitored for shocks produced using a vibration generator

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Fix the EUT to the shaking table directly, or with a fixing jig, in the similar attitude to the actually-fixed state
B. When fixing the EUT with the jig, no looseness or resonance is permitted
C. The cable harness has to be reinforced (fixed) in a distance of 15 ± 2 cm to the connector
D. Measure the applied vibration acceleration at the shaking table or the fixing jig.
E. Place the vibration control on the vibration fixture, the closest to the DUT.
F. Perform 1 successive shock in each axis (X-, X+, Y-, Y+, Z-, Z+) as defined above.
G. 6 shocks in total per DUT

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

9 MS/11 Terminal strength test

Reference: 28401NDS01_10

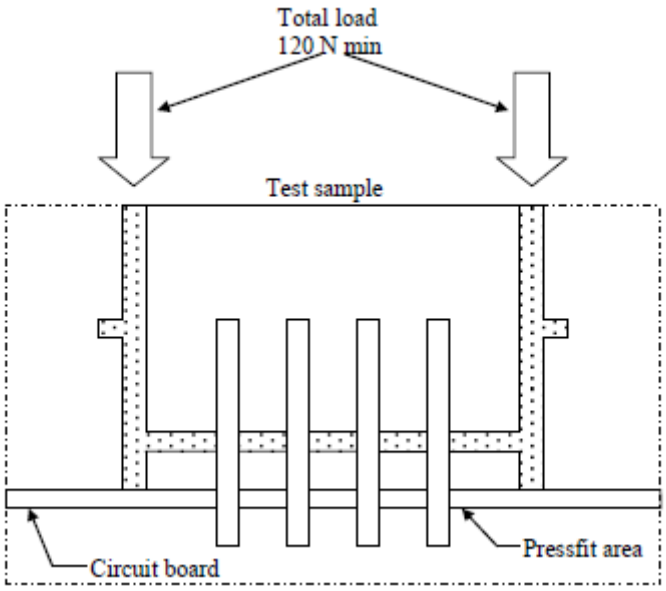
Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: NISSAN 28400NDS00 [7]

Test Parameters:

EUT number	3
Force	120N
Force direction(s):	In mating direction
Number of force applications:	10 times on each temperature
Test temperature	Tmin / RT / Tmax
Operating mode:	1.1
Operating class:	A'
Gravity Level	0

Equipment with a direct insertion type connector



Initial Evaluation of Test:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT.

Evaluation During Test:

Monitor during force application by visual check if mechanical disruption can be found.

Proceeding of Test:

The samples have to be fixed at the original mounting points.
After securing the EUT, apply a load of 120 N MIN to the entire area of the connector housing in the pressing direction of the terminal, and confirm the soldering strength of the terminal. The DUT shall

be supported by the whole area of the case to prevent distortion due to brackets.
Force increase rate of 20mm/min, until max force is reached.
Hold the max force for 2 sec. Apply the force without impact for 10 times at Tmin/RT/Tmax.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

10 CL/01 Thermal Shock Endurance Test

Reference: 28401NDS01_10

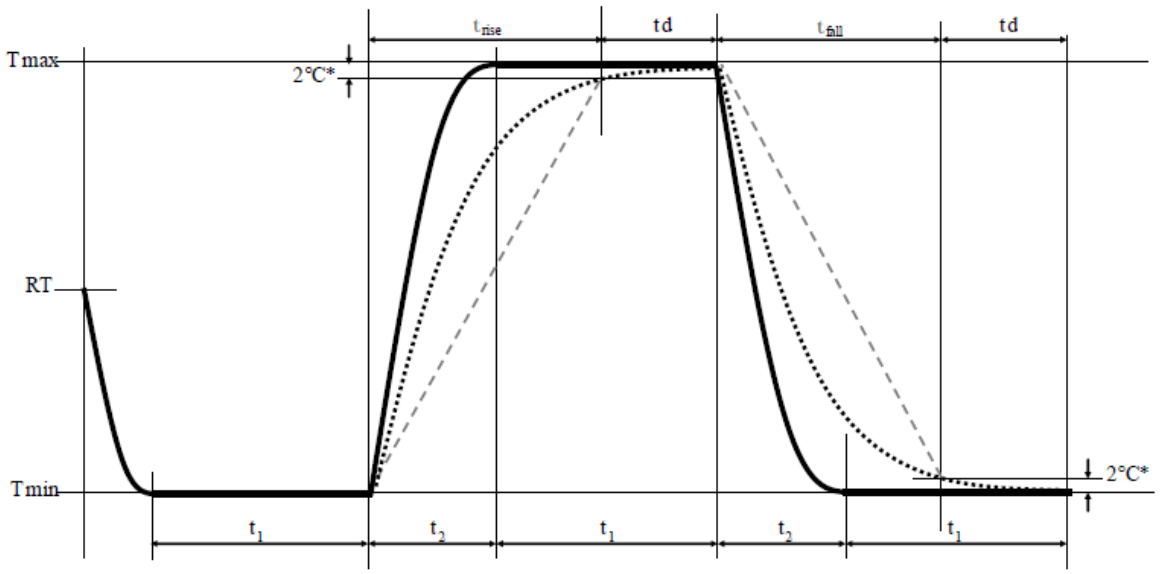
Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: IEC 60068-2-14 Na

Test Parameters:

EUT number	6
Number of Test Cycle (N_{Cycle})	1000
Minimum Chamber Temperature (T_{min})	-40°C
Maximum Chamber Temperature (T_{max})	+105 °C
Holding Time (t_1) at T_{min}, T_{max}	Stabilization time+15 min Stabilization time= 10minutes (from previous qualification agreed by Project Team) Holding time=25min
Transfer Time (t_2) between Chambers	< 30s
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	1.1
Operating Class	A'
Gravity Level	0

Temperature Cycle Profile:



t_1 : Soak time
t_2 : Transition time < 30s
t_{rise} : Rising transition time on PCBs
t_{fall} : Falling transition time on PCBs

* Temperature deemed saturated
Target temperature - 2°C on the hot side
Target temperature +2°C on the cold side

Temperature in the test chamber
Temperature on PCB inside EUT
Approximated temperature slope S_{rise} and S_{fall}

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

Before starting the test, stabilization time must be measured.

A. At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.
B. Place the DUTs in a dual zone thermal shock chamber with mating connectors and adjust the temperature to zones to T_{min} and T_{max}.
C. Maintain the DUTs at temperature T_{min} for the time t_1.
D. Transfer the DUTs from the T_{min} zone to the T_{max} zone within t_2.
E. Maintain the DUTs at temperature T_{max} for the time t_1.
F. Transfer the DUTs from the T_{max} zone to the T_{min} zone within t_2.
G. Repeat the thermal cycles (steps B through F) for a total number of N_{Cycle}.
H. The DUTs shall then remain under standard atmospheric conditions for the attainment of temperature stability.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

11 CL/02 Thermal Shocks Pre-Aging Test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

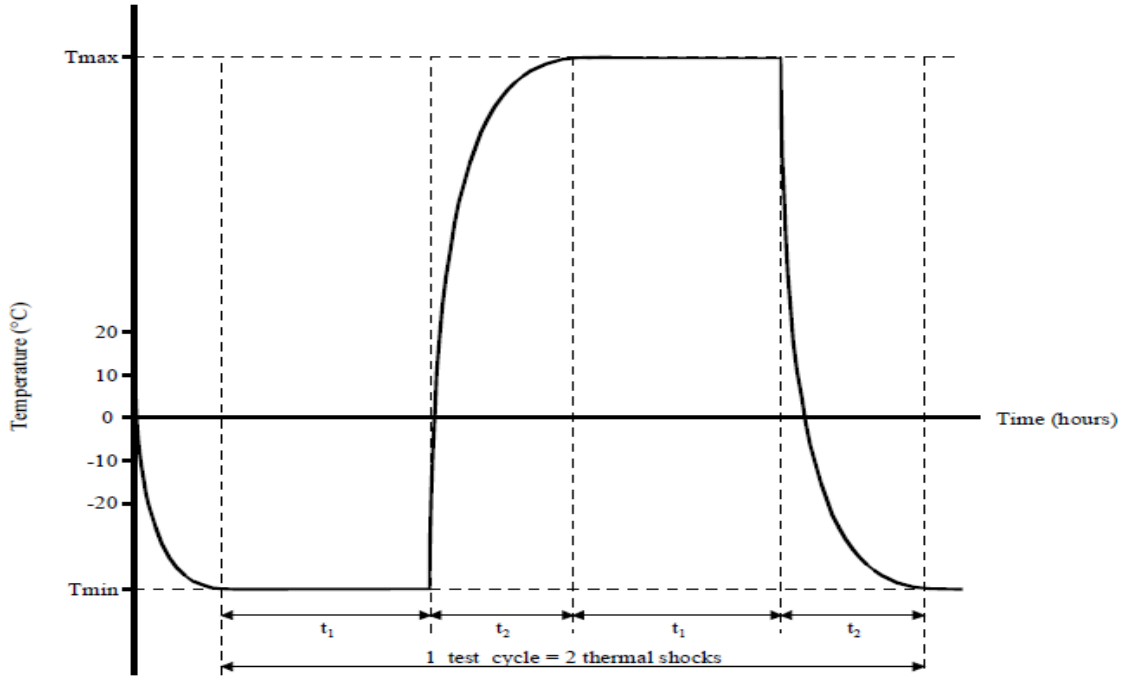
Applicable standards: IEC 60068-2-14 Na

Test Parameters:

EUT number	6
Number of Test Cycle (N_{Cycle})	20
Minimum Chamber Temperature (T_{min})	-40°C
Maximum Chamber Temperature (T_{max})	+105 °C
Holding Time (t_1) at T_{min}, T_{max}	Stabilization time+15 min Stabilization time= 10minutes (from previous qualification agreed by Project Team) Holding time=25min
Transfer Time (t_2) between Chambers	< 30s
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	1.2
Operating Class	A'
Gravity Level	0

Temperature Cycle Profile:

CL/02 Figure 1 : Test cycle.



t_1 : Soak time.
t_2 : Transition time < 30 s.

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

Before starting the test, stabilization time must be measured.

A. At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.
B. Place the DUTs in a dual zone thermal shock chamber with mating connectors and adjust the temperature to zones to T_{min} and T_{max}.
C. Maintain the DUTs at temperature T_{min} for the time t_1.
D. Transfer the DUTs from the T_{min} zone to the T_{max} zone within t_2.
E. Maintain the DUTs at temperature T_{max} for the time t_1.
F. Transfer the DUTs from the T_{max} zone to the T_{min} zone within t_2.
G. Repeat the thermal cycles (steps B through F) for a total number of N_{Cycle}.
The DUTs shall then remain under standard atmospheric conditions for the attainment of temperature stability

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

12 CL/03 Warm Storage

Reference: 28401NDS01_10

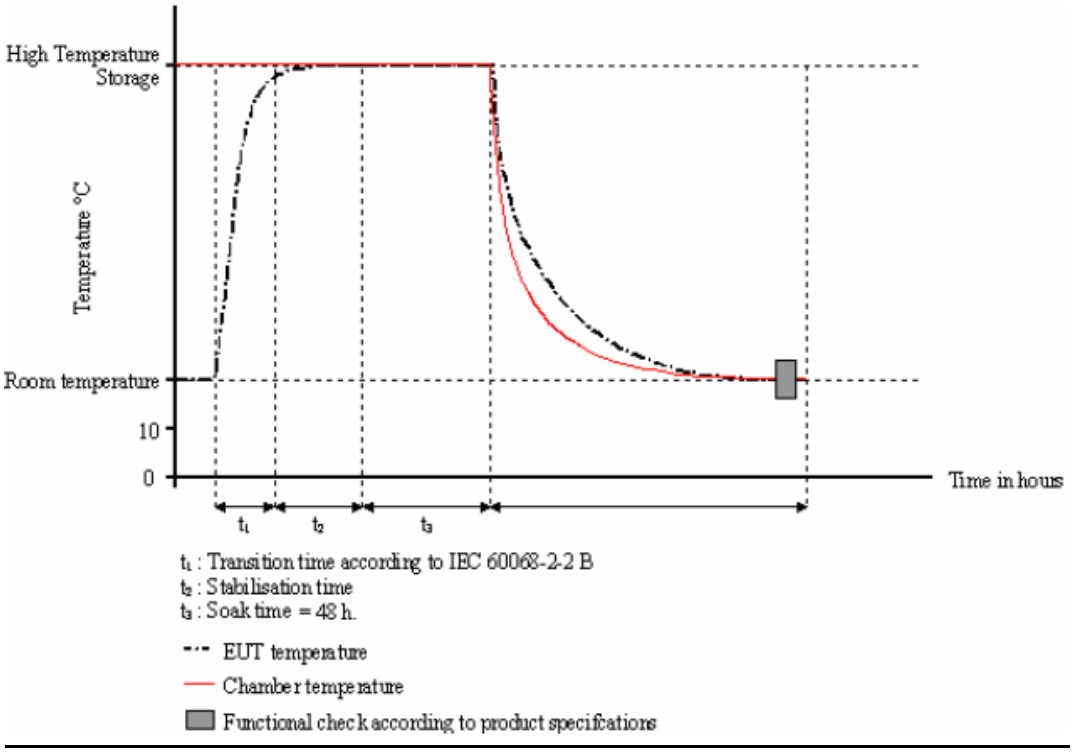
Deviation: The Soak time will be considered after chamber temperature will reach T_{max}.

Applicable standards: IEC 60068-2-2B

Test Parameters:

EUT number	6
Soak time(t_3) at T_{max}	48 h
Rate of Temperature Change (T_{Change})	≤ 1 K/min (average over a period of not more than 5 min)
Maximum Temperature (T_{max})	(+105 ± 2) °C
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	1.1
Operating Classes	A' at R.T.
Gravity Level	0

CL/03 Figure 1 : Description of the test.



Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Place the DUTs (DUT temperature is RT) in the temperature chamber at temperature RT.

B. The temperature in the chamber shall then be adjusted to the temperature T_{max} at a rate of temperature change T_{Change}:
C. Maintain the EUTs at temperature T_{max} for the time t_3. The duration shall be measured from the time when the temperature stability of the chamber is reached.
D. At the end of this period, the EUTs shall remain in the chamber and the temperature shall be gradually lowered at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurements and testing.
E. Remove the EUTs from the chamber.
F. The EUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 2h.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

13 CL/04 Cold Storage

Reference: 28401NDS01_10

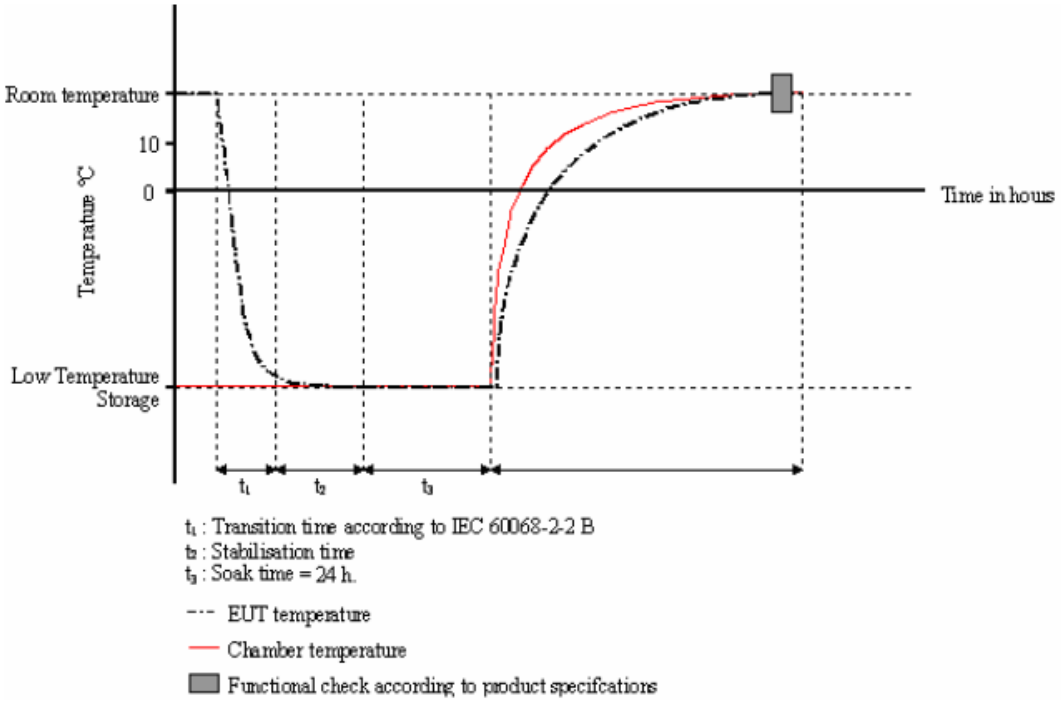
Deviation: The Soak time will be considered after chamber temperature will reach T_{min}.

Applicable standards: IEC 60068-2-1A

Test Parameters:

EUT number	6
Soak time (t_3) at T_{min}	24 h
Rate of Temperature Change (T_{Change})	≤ 1 K/min (average over a period of not more than 5 min)
Maximum Temperature (T_{min})	(-40 ± 2) °C
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	1.1
Operating Classes	A' at R.T.
Gravity Level	0

CL/04 Figure 1 : Description of the test.



Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Place the DUTs (DUT temperature is RT) in the temperature chamber at temperature RT.
B. The temperature in the chamber shall then be adjusted to the temperature T_{max} at a rate of temperature change T_{Change}:

C. Maintain the DUTs at temperature T_{min} for the time t_3. The duration shall be measured from the time when the temperature stability of the chamber is reached.
D. At the end of this period, the DUTs shall remain in the chamber and the temperature shall be gradually adjusted at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurements and testing.
E. Remove the DUTs from the chamber.
F. The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 2h.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

14 CL/06 Climatic sequence

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: IEC 60068-2-38 Z/AD

Test Parameters:

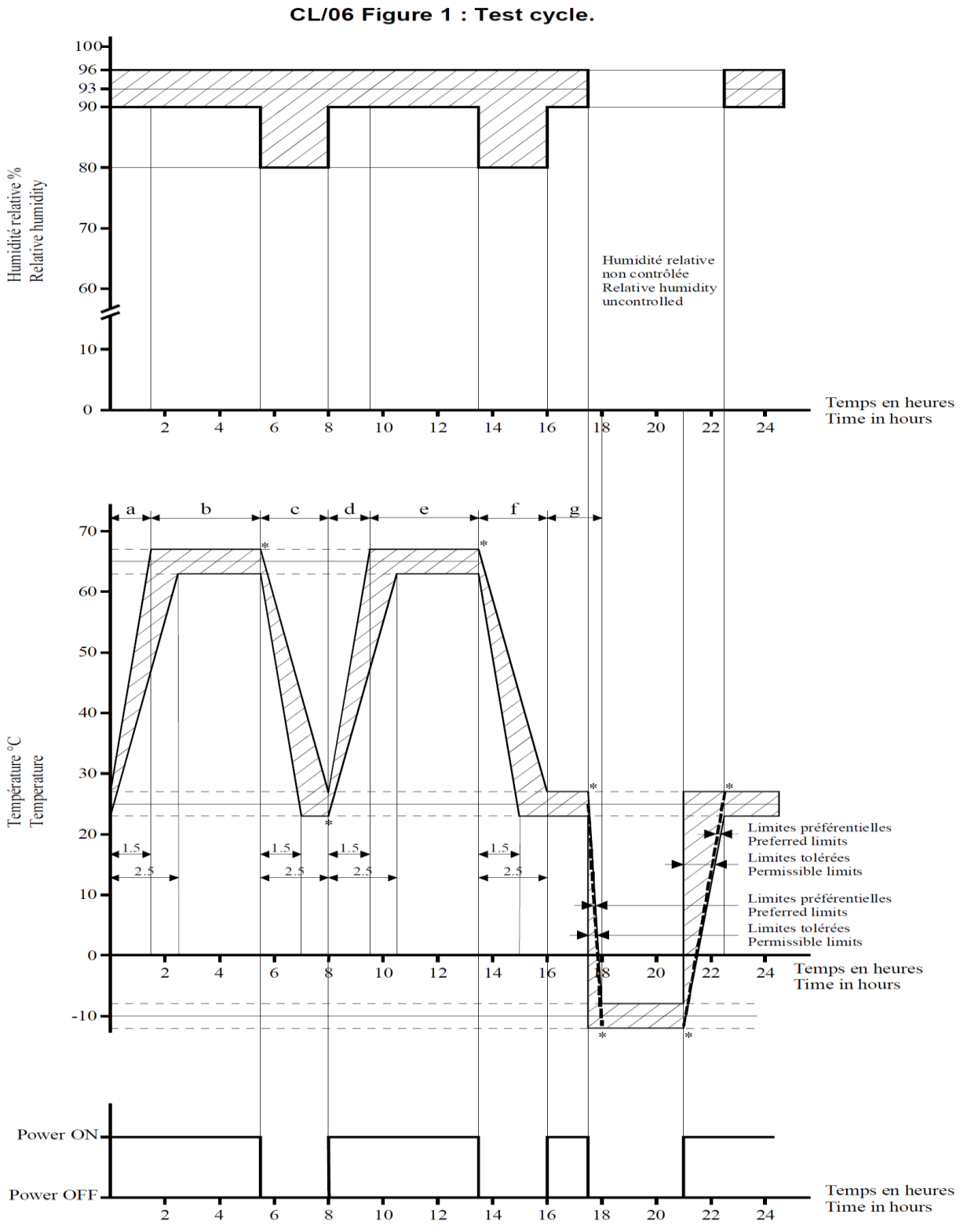
EUT number	4
Total Test Duration	10 d
Test Cycle Duration	24 h
Number of Test Cycle (N_{cycle})	10
Maximum Temperature (T_{max})	(65 ± 2) °C
Minimum Temperature (T_{min})	(-10 ± 2) °C
Relative Humidity (RH_1)	See humidity cycle below
Temperature Reference Point	Ambient temperature (chamber temperature)
EUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operation/Monitoring Mode	3.1/ 3.2 (See profile below)
Operating Classes	A
Gravity Level	0

Test cycles:

CL/06 Table 1 : Test procedure.

Test cycles		Temperature (℃ ± 2℃)	Typical duration (hour)	Relative Humidity (% RH)	Power
10 cycles	2 cycles	25 → 65	2	90 – 96	ON
		65	3,5	90 – 96	ON
		65 → 25	2	80 - 96	OFF
		25	0,5	80 - 96	ON
	1 cycle	25	1,5	80 - 96	ON
		25 → -10	0,5	uncontrolled	OFF
		-10	3	uncontrolled	OFF
		-10 → 25	1,5	uncontrolled	ON
		25	1,5	90 – 96	ON

Humidity Cycle:



* Tolérance sur le temps à ces points ± 5 min
* Tolerance on time at these points ± 5 min.

1cycle = 24h

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Adjust a climatic chamber to a temperature (25 ± 2) °C and relative humidity (93 ± 3) RH.
B. Place the DUT (DUT temperature is RT) in the climatic chamber.
C. Perform 10 cycles of the humidity cycle according to the graph above.
D. On completion of the final cycle, the specimen shall be removed from the chamber and shall be kept under standard atmospheric conditions until temperature stability is reached.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

15 CL/07 Temperature range step test

Reference: 28401NDS01_10

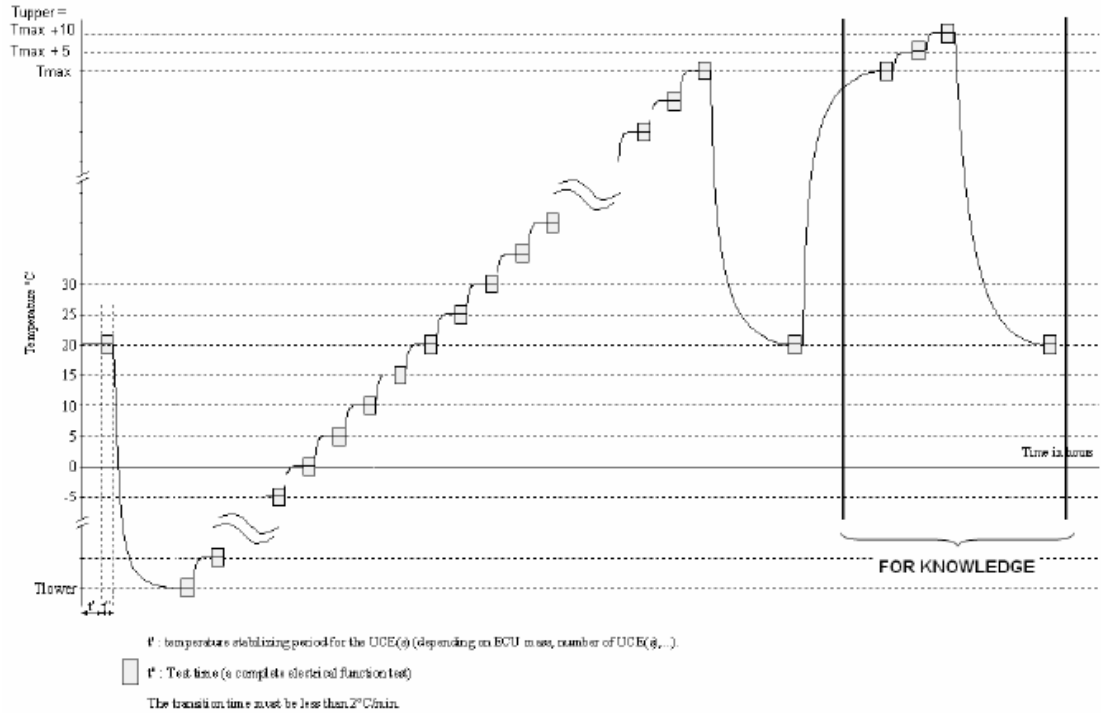
Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: IEC 60068-2-2B
ISO/DIS 16750-4

Test Parameters:

EUT number	6
Minimum Temperature (T_{min})	-40°C
Maximum Temperature (T_{max})	+105 °C
Upper Temperature (T_{upper})	(T_{max} +10ºC)=115ºC
Temperature Steps	5 K
Holding Time (t_1), at each step	30min
Rate of Temperature Change	<2 ºC/min
Voltage (U_{min}, U_{nom}, U_{max})	Umin= 9V, Unom=13.5V, Umax=16V
DUT Test Position	Not relevant
Operation/Monitoring Mode	3.2(for functional test) / 1.2 (rest of the time)
Operating class	A
Gravity Level	0

Temperature profile:



Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Place the EUT in the temperature chamber and stabilize the temperature at RT.
B. Decrease the temperature in steps of 5 °C from RT to T_{min} and then increase the temperature in steps of 5°C from T_{min} to T_{max}.
   Wait at each step, until the EUT has reached the new temperature.
   Perform a functional test using operation mode 3.2 at $U_{min,}$ U_{nom} and U_{max}, at each temperature step.
   Between the temperature steps (temperature in-/decrease the EUT shall be switched OFF).
C. Return the EUT to room temperature (RT).

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

16 CL/08 Warm Operation

Reference: 28401NDS01_10

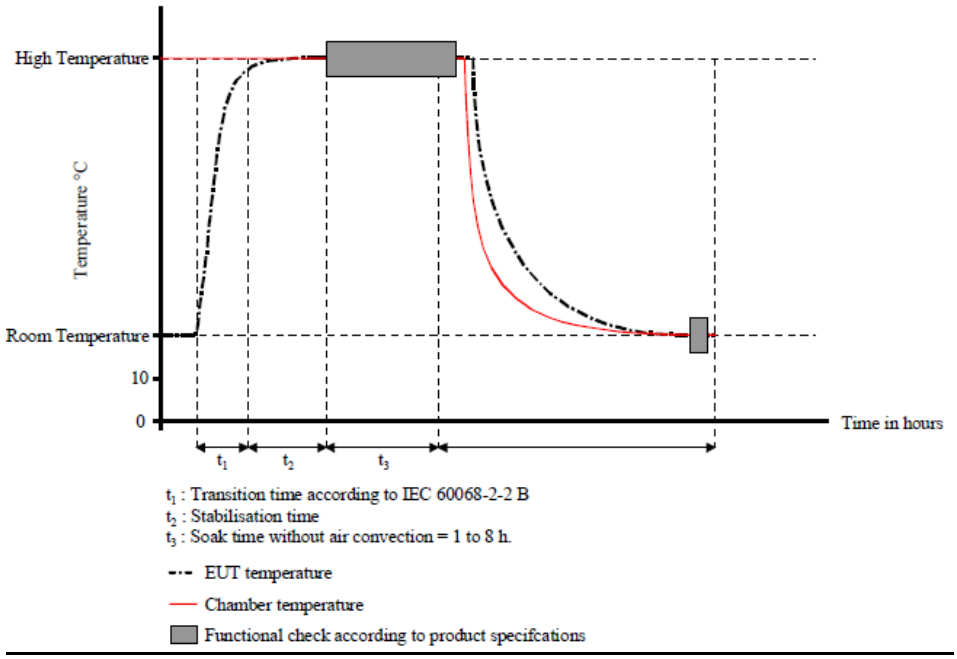
Applicable standards: IEC 60068-2-2B

Test Parameters:

EUT number	6
Test Duration (t_3) at T_{max}	8 h
Rate of Temperature Change (T_{Change})	≤ 1 K/min (average over a period of not more than 5 min)
Maximum Temperature (T_{max})	(+105 ± 2) °C
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	3.2
Operating Classes	A
Gravity Level	0

Temperature profile:

CL/08 Figure 1 : Description of the test.



Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Place the DUTs (DUT temperature is RT) in the temperature chamber at temperature RT.
B. The temperature in the chamber shall then be adjusted to the temperature T_{max} at a rate of temperature change T_{Change}:
C. Maintain the DUTs at temperature T_{max} for the time t_3. The duration shall be measured from the time when the temperature stability of the chamber is reached.

D. At the end of this period, the DUTs shall remain in the chamber and the temperature shall be gradually lowered at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurements and testing.
E. Remove the DUTs from the chamber.
F. The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 2h.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

17 CL/09 Cold Operation

Reference: 28401NDS01_10

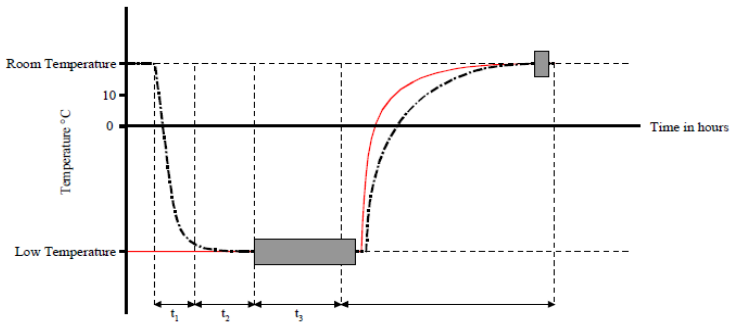
Applicable standards: IEC 60068-2-1

Test Parameters:

EUT number	6
Test Duration (t_3) at T_{min}	24 h
Rate of Temperature Change (T_{Change})	≤ 1 K/min (average over a period of not more than 5 min)
Minimum Temperature (T_{min})	(-40 ± 2) °C
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	3.2 with IGN ON/ OFF (see Operation Profile below)
Operating Classes	A
Gravity Level	0

Temperature profile:

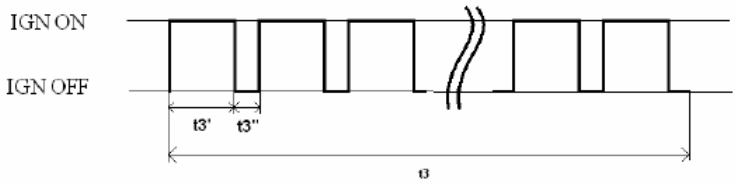
CL/09 Figure 1 : Description of the test.



t_1 : Transition time according to IEC 60068-2-2 B
t_2 : Stabilisation time
t_3 : Soak time without air convection = 24 h.

EUT temperature
Chamber temperature
Functional check according to product specifcations

Operation profile:



t3 = 24 h
t3' = 1 h as a minimum
t3'' = time required for the EUT to be again at Tmin
Number of ON/OFF cycles : 12 as a minimum

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test Procedure:

A. Place the EUTs (DUT temperature is RT) in the temperature chamber at temperature RT.
B. The temperature in the chamber shall then be adjusted to the temperature T_{min} at a rate of temperature change T_{Change}:
C. Maintain the EUTs at temperature T_{min} for the time t_3. The duration shall be measured from the time when the temperature stability of the chamber is reached.
D. Operate de EUT as per above Operating profile.
E. At the end of this period, the EUTs shall remain in the chamber and the temperature shall be gradually adjusted at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurements and testing.
F. Remove the EUTs from the chamber.
G. The EUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 2h.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature.

18 CL/13 : Check Saturation Temperature

Reference: 28401NDS01_10

Applicable standards: 28401NDS01[1] 3-2-1

Test parameters :

EUT number	2
Maximum Temperature (T_{max})	(+105 ± 2) °C
Operation/Monitoring Mode	2.1/ 3.2
Operating Classes	A
Gravity Level	0

Initial Evaluation of Test:

Conduct a visual inspection, size check and function confirmation of the EUT.

Test procedure:

A. Place the EUT in a thermostatic chamber at room temperature, and connect the input unit and the load outside of the chamber to operate the EUT.
B. Increase the temperature in the chamber gradually to the specified value (Tmax=+105ºC). When the temperature has reached the specified value Tmax=+105ºC, leave the EUT to stand at that temperature for 1 ± 0.5 h (operation mode 2.1).
C. Then, operate the EUT (operation mode 3.2) until the temperature rises and reaches the saturation point due to heat from the EUT itself.
D. Then, measure and record the saturation temperature and the time required for saturation at each measurement points.

The following shall be noted during this confirmation test.

Instalation of equipment

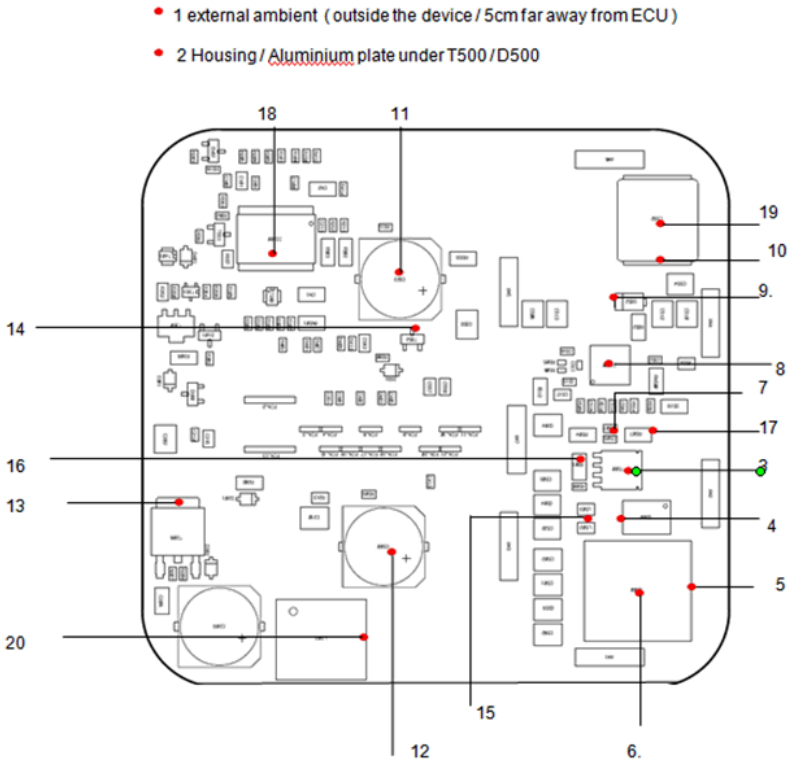
The load shall be connected (in Method 1, the input unit and the load equivalent to actual load shall be connected outside of the thermostatic chamber) to operate the EUT. The assembly direction of the EUT shall be the same in the actual conditions. When radiation of heat from the applicable electronic equipment is prevented due to its structure, such structure shall be simulated when the EUT is assembled. As for temperature sensors to be installed, a bare thermocouple shall be used in which the thermal capacity is considerably lower than the one of the EUT, so the ambient temperature is not affected.

In Method 1, if it is clear that the load location in the actual vehicle is the same as the layout of the EUT and the load, the load can be placed in the thermostatic chamber during this test.

Note: Air convection test chamber has to be used in order to maintain temperature according to test requirements. EUT shall be placed inside a box (metal or cardboard) in the test chamber in order to avoid cooling of the sample by air convection. Thermocouples will be inserted through holes drilled in the housing. The cover of the housing will be mounted in order to simulate the real life situation.

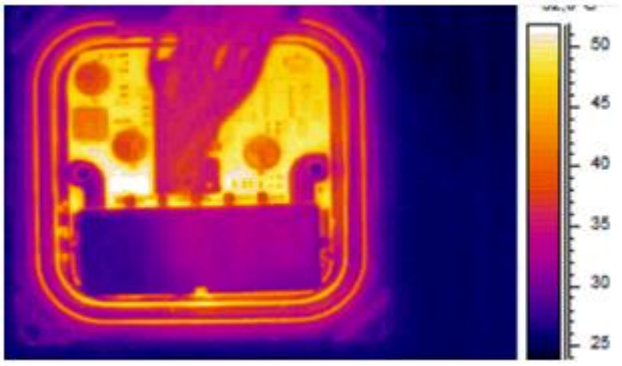
Selection of temperature measurement points

Remark: Agreed by Project Team that the below measurements points to be used).



A thermal picture of the LDM was performed in order to check the hottest components.
Additionally, by experiences, we know that the parts of the Buck and the Boost Converter are the hottest.
So, we placed thermo sensors on the components of the buck and booster with high power dissipation, on the input MOSFET and on the coil (power dissipation was expected to be high).

Hereafter the thermal picture performed with IF camera to allow us to determine the hottest components:



Final measurement:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT.

19 CL/15: Continuous Dewing Test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Test Parameters:

EUT number	6
Test Duration	Td=1000h
Number of cycles	1
Test Temperature	+40± 2ºC
Test chamber humidity	95 ± 5 % RH
EUT orientation	See drawing chapter
Operation/Monitoring Mode	1.2
Operating Classes	Class A'
Gravity Level	0

Initial Evaluation of Test:

Conduct visual inspection, electrical performance inspection and function confirmation of the EUT only at RT.

Test Procedure:

Operation term
- Put the EUTs in a thermostatic chamber which is set at Room Temperature (RT).
- The EUT is not operational mode.(IGN OFF)
- Set the test chamber at a temperature of **40**±2°C and relative humidity of **95**±5%RH and leave these test conditions for 1000h or more.

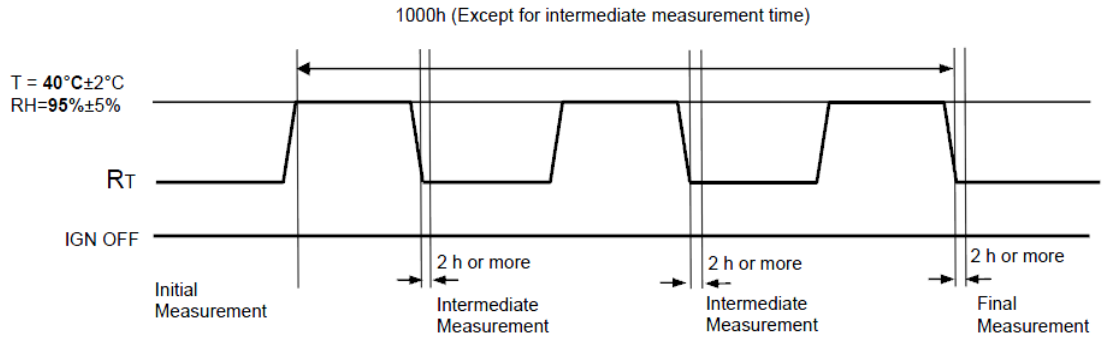
Intermediate measurement:
- The EUT must be checked minimum two times during the test.

Example:
－first check at 300h from beginning
－second check at 600h from beginning

At this intermediate measurement, before conducting inspection, take out EUTs from chamber , leave EUTs at RT (Room Temperature) for 2 hours or more. Then, according to the specified product standard, conduct visual inspection, electrical performance inspection and function confirmation of the EUT at RT and Toperating min.(EUTs shall not be tested more than 30degree)

Specific requirements to complete this testing :

Before executing CL/15, EUT should not be exposed to more than 30 Celsius degrees.



Acceptance Criteria:

Before conducting inspection, leave EUTs at RT for 2 hours or more. Then, conduct visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature

20 LT/00: Self Heating Temperature Measurement

Reference: 28401NDS01_10

Test Parameters:

EUT number	2
Maximum Temperature (T_{max})	(+105 ± 2) °C
Operation/Monitoring Mode	3.2
Operating Classes	A
Gravity Level	0

Initial Evaluation of Test:

Conduct visual inspection, electrical performance inspection and function confirmation of the EUT only at RT.

Test procedure :

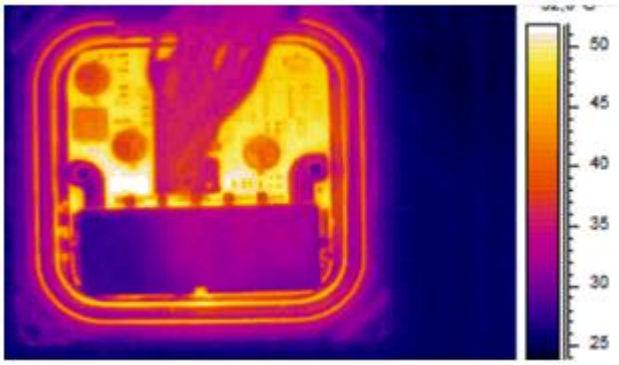
Place the EUT in a thermostatic chamber, and connect the input units and the loads outside of the chamber to operate the EUT. The assembly direction of the EUT shall be the same as for future position in the vehicle.

1.Determination of the measurement points :

Remark: Agreed by Project Team that the below measurements points to be used.

A thermal picture of the LDM was performed in order to check the hottest components.
Additionally, by experiences, we know that the parts of the Buck and the Boost Converter are the hottest.
So, we placed thermo sensors on the components of the buck and booster with high power dissipation, on the input MOSFET and on the coil (power dissipation was expected to be high).

Hereafter the thermal picture performed with IF camera to allow us to determine the hottest components:



2. Instrumentation / measurements to perform :

Now, instrument a sample with thermocouples to measure the ambient temperature of the chosen components. The thermal sensors have to be placed above components, at a distance of about 1 cm. If the housing is too close to the component, then place the sensor at the middle of the distance component housing.

Method 1:

Operate to cause the maximum heat conditions which are expected during actual operation by users.

3. Calculation of ΔTeq :

For each measurement point we will have a value for the temperature measured (ambient temperature of the chosen point Tamb) and a value for the external temperature corresponding to the air temperature(Tair). ΔTeqi for each point is calculated using the following formula:

$$\Delta Teq_i = Tamb_i - Tair_i$$

Then for calculating the ΔT self heating temperature value (ΔTeq) use the following formula:

Method 1 :

$$\Delta Teq = Max(\Delta Teq_1, \Delta Teq_2, \dots, \Delta Teq_n)$$

Validation report :

The validation report must contain at least the information defined in the paragraph 8.8.

Especially for Temperature equivalent evaluation (LT/00) Renault/Nissan require to add the following information:

- Some pictures / photos to see where the sensors have been located,
- The curves of these sensors to see the temperature rise,
- Table with all saturation values
- Infra red thermography pictures for each profile,
- Results of simulation if applicable.
- Value of the specification compared to average temperature of element.

Acceptance Criteria:

Renault/Nissan require to have knowledge of the self-heating temperature (ΔTeq) for each profile and the self-heating temperature, to be used for determining the conditions of life test LT/01 and LT/03.

21 LT/01: Thermal Cycling Life Test

Reference: 28401NDS01_10

Deviation: Stabilization time (for tt= 10ºC/min) = 10minutes

Test parameters:

EUT number	6
Durability level	M
ECU mounting location code	III
ΔTeq	Hypothesis **15°C < ΔTeq ≤ 20°C**
Thermal cycles to perform	Nf = no. of cycles will be calculated considering ΔTeq (see example below)
Test duration	No. of hours will be calculated considering ΔTeq (see example below)
EUT test position	See chapter Drawing
Minimum air chamber temperature (Tr lower)	-40 °C
Maximum air chamber temperature(Tr upper)	+105 °C
td (stabilization time of the DUT)	10 min- Provided by project team
tc (soak time at Tr lower and Tr upper)	15min + td (stabilization time of the DUT)
tt (rate of air temperature change)	10°C/min
Operating mode:	1.2
Operating Classes	A ‘

Test parameters:

LT/01 Table 2 : Power Off test cycles for III, 6/8-cylinder engine.

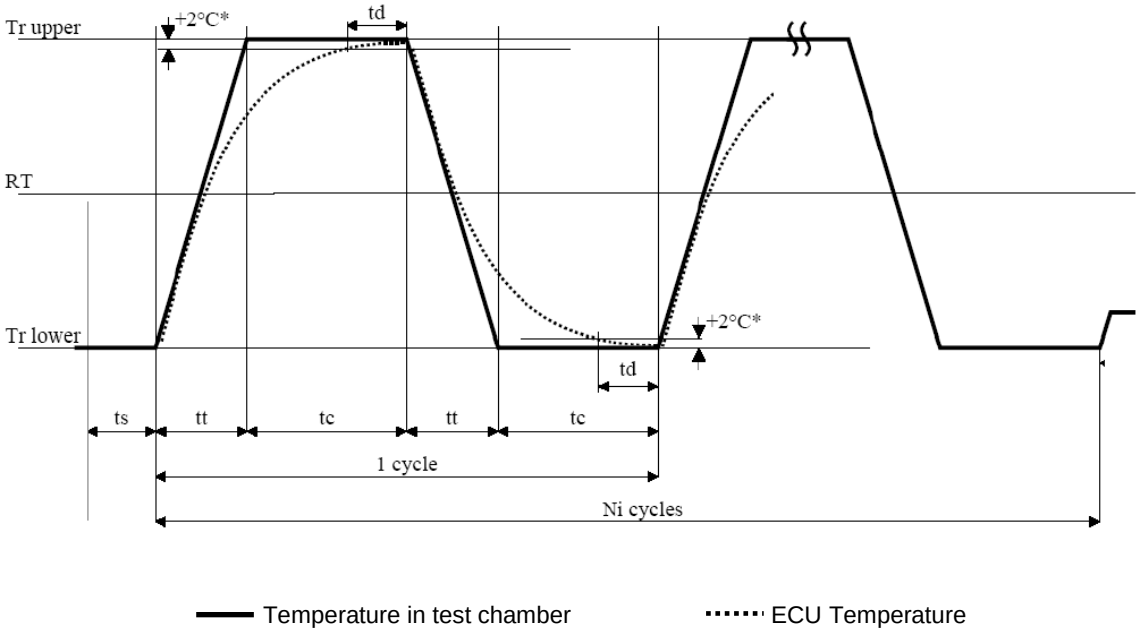
(Body side in engine compartment, ΔT = 160℃ where Tr_{lower}=-40℃ and Tr_{upper}=+120℃) unit: cycle

		Durability level								
		H			M			L		
		18℃ < ΔTeq ≤ 25℃	10℃ < ΔTeq ≤ 18℃	ΔTeq ≤ 10℃	18℃ < ΔTeq ≤ 25℃	10℃ < ΔTeq ≤ 18℃	ΔTeq ≤ 10℃	18℃ < ΔTeq ≤ 25℃	10℃ < ΔTeq ≤ 18℃	ΔTeq ≤ 10℃
EUT number	3	2740	2110	1505	1830	1405	1005	915	705	500
	6	2175	1640	1140	1450	1095	760	725	550	380
	8	1900	1415	970	1270	945	650	635	470	325
	20	1460	1060	705	970	705	470	490	355	235

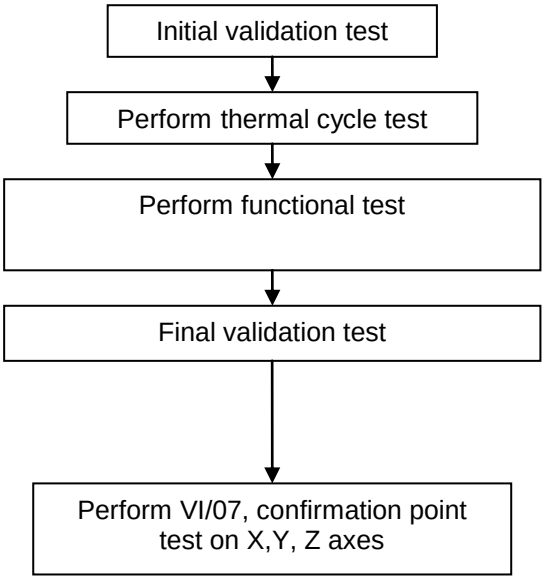
LT/01 Table 5 : Number of test cycles ratio γ according to test temperature difference conditions.

Test temperature difference ΔTr (°C)	Lower and upper limit temperatures	Number of test cycles ratio γ	
		I and II	III and IV
160	-40 to 120°C	0.48	1
155	-40 to 115°C	0.52	1.1
150	-40 to 110°C, -30 to 120°C	0.58	1.2
145	-40 to 105°C	0.64	1.3
140	-40 to 100°C, -30 to 110°C	0.7	1.5
135	-40 to 95°C	0.8	1.7
130	-40 to 90°C, -30 to 100°C	0.9	1.9
125	-40 to 85°C, -25 to 100°C	1	2.1
120	-40 to 80°C, -35 to 85°C	1.1	-
115	-35 to 80°C, -30 to 85°C	1.3	-
110	-40 to 70°C, -25 to 85°C	1.5	-
105	-35 to 70°C, -20 to 80°C	1.7	-
100	-30 to 70°C	2.0	-
95	-25 to 70°C	2.3	-

Thermal cycle profile:



Sequence:



Initial Evaluation of Test:

According to the specified product standard, conduct visual inspection, electrical performance inspection and function confirmation of the EUT.
Before performing this test, it is necessary to evaluate
the self heating of the ECU applying the test LT/00 of this specification. This allows calculating the number of cycles to use for LT/01.

Test procedure:

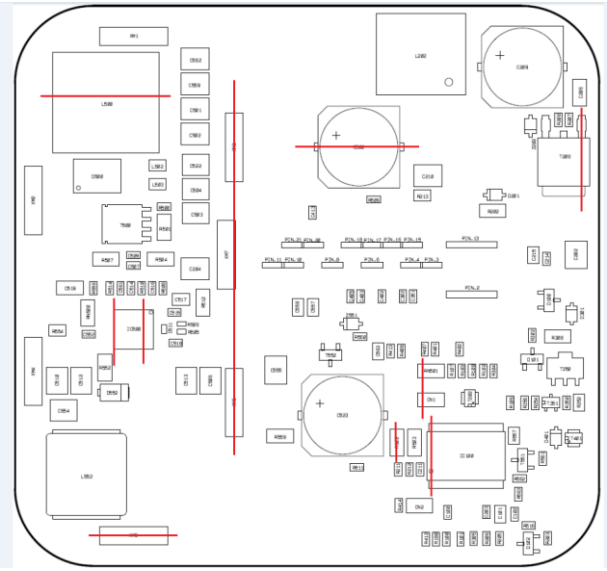
A. Using a thermocouple measure the stabilization time of the DUT. The temperature stabilization is reached when the temperature of the product is equal to the required temperature ± 2ºC.
B. Subject the DUT to N_{Cycle} between Tr lower and Tr upper according to the graph above.
C. At 20%, 40%, 60%, 80%, of test perform an Operation Check(Functional test)
D. The DUTs shall then remain under standard atmospheric conditions for the attainment of temperature stability.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

Specific requirements to complete this testing :

- Renault/Nissan require the supplier
- To perform Confirmation point test of VI/07 to confirm proper operating of ECU after LT/01 test.
- To vibrate ECU by performing Confirmation Point test of VI/07 on X, Y, Z axes, 15min. minimum per axis.
- To carry on the test until the failure of all the samples in order to get a Weibull analyze in case of failures during test.
- To perform micro sections on solder joints in order to detect any crack . On each components family as per below drawing :



Remark: Cross-section points based on project team judgement:

The cross sections are performed on each component family to be representative of all components on our product. The purpose is to check the quality of each type of solder joints . So, we have chosen to check following solder joints:

- the biggest coil (L500)
- the QFN (IC component) because solder pads are under the component (IC500)
- one of a capacitor array (CN1)
- one of a network resistor (RN501), which is near the capacitor array (CN1) to perform one micro section for both
- the biggest transistor (T206)
- one of Electrolytic capacitor (C500) which is representative of all electrolytic capacitors
- fix point of shield (XM3, XM7, XM5 and XM6)
- big size resistor above 3216(3.2mm × 1.6mm) (R502)
- big size IC (IC100)

Example for Test duration calculation:

ECU mounting location class: III
Durability level: M (10 years)
ECU number: 6
Life temperatures for DUT: -40 ºC to +105ºC => ΔTr 145ºC

ΔTeq =16.26 ºC (measured at LT/00 test) Value available from previous qualifications
Stabilization time (for tt 10ºC/min) = 10minutes Provided by project team.

for 10°C < ΔTeq ≤ 18°C => Ni= 1095 cycles (see LT/01 Table 2 above)

We have (-40 ºC to +105ºC) => ΔTr 145ºC => γ=1.3 (see LT/01 Tabel 5 above)

So, total number of cycles N=Ni* γ=1095 x 1,3= 1424 cycles

Total test duration= N x 1cycle duration
1 cycle duration= 14,5min+ (10+15minute)+14,5min+(10+15min)= 79minutes

Total test duration= 1424cycles x 79min/cycle= 1875 h

22 LT/03: Thermal Life Test

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Test parameters:

Durability level	**M**
ECU mounting location code	**III**
ECU number	**N =6**
ΔTeq	Hypothesis **15°C < ΔTeq ≤ 20°C**
Air chamber high temperature	Tr off = +125 °C
Air chamber low temperature	Tr on = +105 °C
Temperature transfer gradient	(R.T.) to (Tr off) & (Tr on) to (R.T.) =>10ºC / min (Tr off) to (Tr on) & (Tr on) to (Tr off) => 5ºC / min
1 Cycle duration	178.4 minutes - provided by project team
Number of cycles (N_{cycles})	500 - provided by project team
Test duration	No. of hours will be calculated considering ΔTeq (see example below)
Shall simulate that used in the vehicle.	
Operating mode:	1.2 (IGN OFF) / 3.2 (IGN ON)
Functional monitoring during test:	Yes
Operating Classes	A
Climatic chamber air flow	2 m/sec

Test set up & test sequence (see test pattern IGN ON IGN OFF next page):

1. Use fresh and serial production representatives harnesses
2. Set chamber temperature at room temperature.
3. Equip ECU with housing, assembly interface (fastening feature)
4. Put equipped ECU inside chamber at R.T.
5. Fix cable harnesses in car mounting representative position
6. Raise temperature from (R.T). to (Tr off) with a temperature transfer gradient of 10ºC/min
7. Leave the ECU without operating at (Tr off) for (1h)
8. Continue leaving the ECU in IGN OFF mode for t_1 duration
9. After t_1 duration, decrease temperature from (Tr off) to(Tr on) with a temperature transfer gradient of 5ºC/min
10. When air chamber temperature has reached (Tr on), start operating ECU in IGN ON mode for t_2 duration
11. After t_2 duration, increase temperature from (Tr on) to (Tr off) with a temperature transfer gradient of 5ºC/min
12. Repeat steps 8 to 11
13. At 20%, 40%, 60% and 80% of test, perform an Operation check (Functional test)
14. Before Operation check (Functional test), decrease temperature from (Tr on) to (R.T.) with a temperature transfer gradient of 10ºC/min, leave the ECU at (R.T.) for a period adequate for the attainment of ECU temperature stability (>=2h) before Operation check
15. At the end of test, decrease temperature from (Tr on) to (R.T.) with a temperature transfer gradient of 10ºC/min, leave the ECU at (R.T.) for a period adequate for the attainment of ECU temperature stability (>=2h) and then perform the Final measurement.

Test parameters:

LT/03 Table 3 : Test time Hoffi for III (body side in engine room, IGN off), 6/8-cylinder engine

unit: hour

		Durability level								
		H			M			L		
		Tr off= 150℃	Tr off= 125℃	Tr off= 105℃	Tr off= 150℃	Tr off = 125℃	Tr off = 105℃	Tr off = 150℃	Tr off = 125℃	Tr off = 105℃
EUTs number	3	300	995	-	200	660	-	100	330	-
	6	245	820	-	165	550	-	80	275	-
	9	220	730	-	150	490	-	70	245	-
	20	175	590	1695	120	390	1130	60	195	565

In case of other durability level, it is necessary to multiply by the coefficient corresponding to real target of the product to know the duration (see LT Table 2 : Conversion table.).

LT/03 Table 4 : Test time Honi for III (body side in engine room, IGN on), 6/8-cylinder engine.

Unit: hour

		Durability level								
		H			M			L		
		Tr on= 150℃	Tr on= 125℃	Tr on= 105℃	Tr on= 150℃	Tr on= 125℃	Tr on= 105℃	Tr on= 150℃	Tr on= 125℃	Tr on= 105℃
EUTs number	3	-	420* $\alpha_{\Delta T}$	1060* $\alpha_{\Delta T}$	-	280* $\alpha_{\Delta T}$	705* $\alpha_{\Delta T}$	-	140* $\alpha_{\Delta T}$	350* $\alpha_{\Delta T}$
	6	-	345* $\alpha_{\Delta T}$	870* $\alpha_{\Delta T}$	-	230* $\alpha_{\Delta T}$	580* $\alpha_{\Delta T}$	-	115* $\alpha_{\Delta T}$	290* $\alpha_{\Delta T}$
	9	-	310* $\alpha_{\Delta T}$	780* $\alpha_{\Delta T}$	-	205* $\alpha_{\Delta T}$	520* $\alpha_{\Delta T}$	-	105* $\alpha_{\Delta T}$	260* $\alpha_{\Delta T}$
	20	-	250* $\alpha_{\Delta T}$	625* $\alpha_{\Delta T}$	-	165* $\alpha_{\Delta T}$	420* $\alpha_{\Delta T}$	-	80* $\alpha_{\Delta T}$	210* $\alpha_{\Delta T}$

In case of other durability level, it is necessary to multiply by the coefficient corresponding to real target of the product to know the duration (see LT Table 2 : Conversion table.).

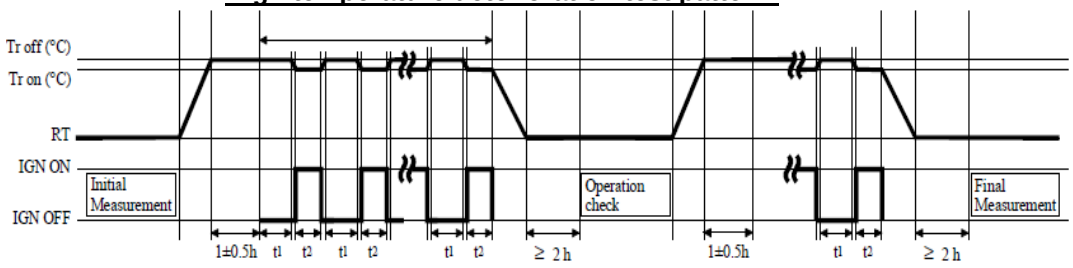
LT/03 Table 7 : Compensation coefficient $\alpha_{\Delta T}$ depending on temperature rise due to self heating ΔTeq.

ΔTeq : Temperature rise due to self heating	$\alpha_{\Delta T}$: Compensation coefficient
0℃ ≤ Δteq < 5℃	1
5℃ ≤ Δteq < 10℃	1.25
10℃ ≤ Δteq < 15℃	1.38
15℃ ≤ Δteq < 20℃	1.5
20℃ ≤ Δteq < 25℃	1.6
25℃ ≤ Δteq < 30℃	1.7
30℃ ≤ Δteq < 35℃	1.8
35℃ ≤ Δteq < 40℃	1.9

LT/03 Table 9 : Correction rate γ for III and IV.

Changed test temperature Tr' (°C)	Test temperature Tr from **LT/03 Table 3** to LT/03 Table 6					
	150°C →Tr'		125°C →Tr'		105°C →Tr'	
	IGN OFF	IGN ON	IGN OFF	IGN ON	IGN OFF	IGN ON
150	**1.0**	**1.0**	-	-	-	-
145	1.3	1.2	-	-	-	-
140	1.6	1.5	-	-	-	-
135	2.0	1.8	-	-	-	-
130	2.6	2.3	-	-	-	-
125	3.3	2.8	**1.0**	**1.0**	-	-
120	4.3	3.5	1.3	1.3	-	-
115	5.6	4.4	1.7	1.6	-	-
110	7.4	5.6	2.2	2.0	0.8	0.8
105	9.8	7.1	2.9	2.5	**1.0**	**1.0**
100	13.1	9.1	3.9	3.2	1.3	1.3
95	17.6	11.7	5.3	4.2	1.8	1.7
90	23.8	15.1	7.1	5.4	2.4	2.1
85	32.5	19.8	9.8	7.0	3.3	2.8

High temperature deterioration test pattern:



Test sequence IGN ON / IGN OFF for:

t1 (OFF)= 66 min - provided by project team
t2 (ON)= 104.4 min - provided by project team
tt (transition time)=4 min

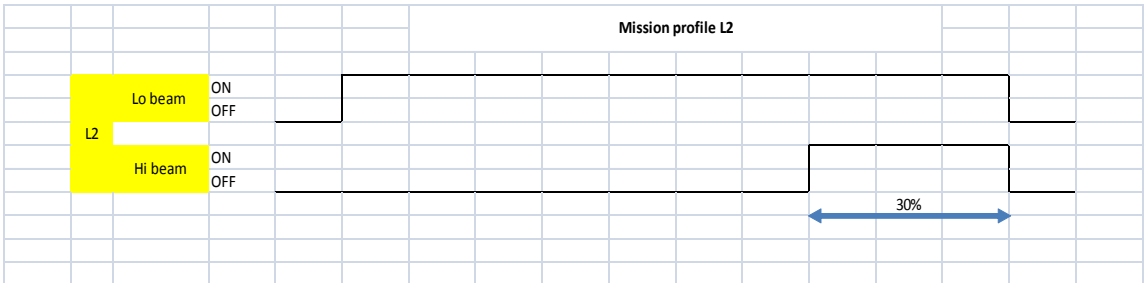
One cycle duration= tt + t2 + tt + t1 = 178,4 min

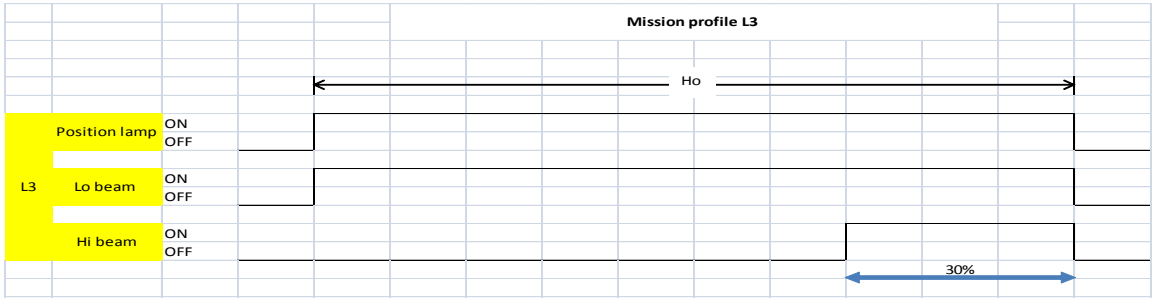
N_{cycle}=500 cycles - provided by project team

Additional note for IGN ON:

For L2 : 70% LB - 30% LB+HB

Mission profile for L2 and L3 variants





Example for Test duration calculation:

ECU mounting location class: III
Durability level: M (10 years)
ECU number: 6
$\alpha\Delta T$ = 1.5

For Tr off= 125ºC

Duration of Tr OFF = **550h x 1** (see LT/03 table 9)= **550h** - provided by project team

For Tr on =105ºC

Duration of Tr ON =Hoff= **580h x $\alpha\Delta T$.**

Duration of Tr ON =Hon= **580h x 1,5=870h** - provided by project team

Test duration= Hoff+ Hon= 550+870h=**1420h (~ 8.5 CW)**

Total duration (Init test + LT03 + 4 intermediate Operation check + final test)=
= 1 w + 8,5w + 1 w + 1 w ~ 11,5 weeks

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

23 LT/02 : Constant Humid Heat Life Test

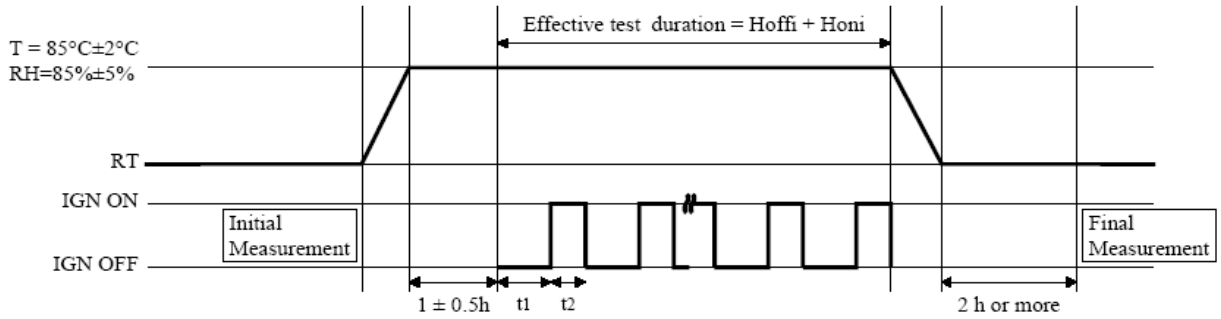
Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Test parameters:

Durability level	M
ECU mounting location code	III
ECU number	N = 3
Test duration	Td = 1000 hours (IGN Off 918h, IGN On 82h) Td value requested by project team
ECU orientation	Original mounting position.
Air chamber temperature	T = +85 °C
Air Chamber relative humidity	RH = 85 %
Operating mode:	3.2
Functional monitoring during test:	Yes
Operating Classes	A

Thermal cycle profile:



Renault/Nissan require a minimum of 1000 hours, whatever the position of the ECU is, for at least 3 samples.

Duration for t1 (IGN Off) and t2 (IGN On)

N= 4110 cycles

Duration IGN Off total = 918h
=> t1=918 h/4110 cycles= 13,5 minutes

Duration IGN On total = 82h
=> t2=82 h/4110 cycles= 1,2 minutes

Initial Evaluation of Test:

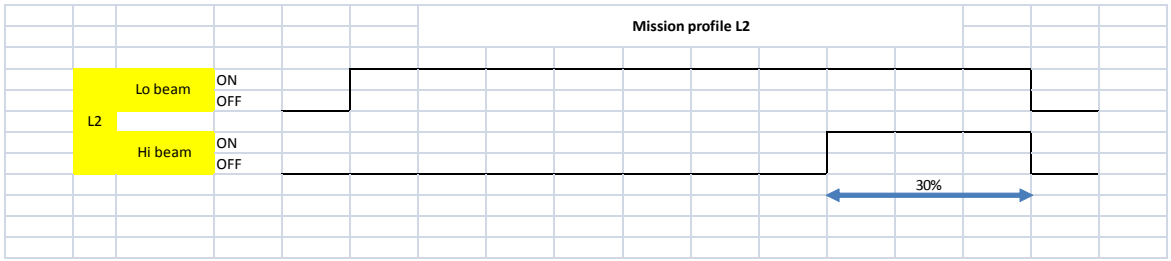
Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

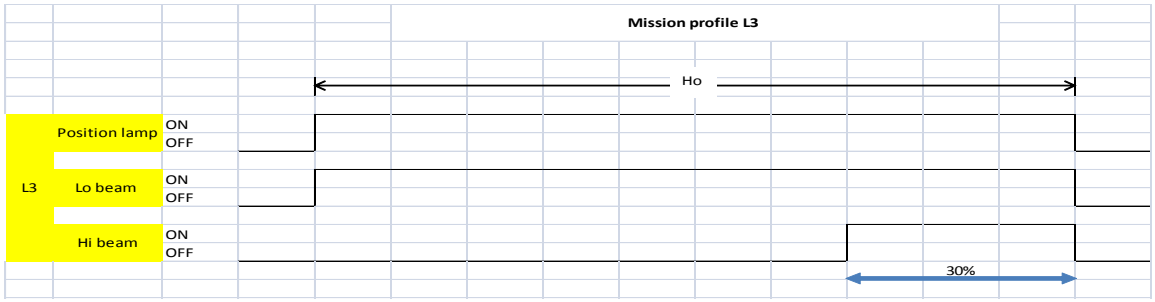
Test procedure:

A. Place equipped DUT inside chamber.
B. Set chamber at temperature T and relative humidity R.H.
C. Maintain and operate according to test parameters and sequence above.
D. Perform an Operation check (Functional test) at 1/3 and 2/3 of Td.

E. Leave the DUT without operating at R.T. for a period adequate for the attainment of temperature stability before parametric test.

Mission profile for L2 and L3 variants





Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .

Specific requirements to complete this testing :

Moreover, the final whisker inspection must be performed on unsealed ECUs, with dedicated optical devices. Firstly, a minimum magnification of x 50 is required to inspect the risky area (fine pitch components or connectors for example). Then, a SEM inspection is necessary to validate the length of the whiskers.

24 CH/12: Corrosive Atmosphere

Reference: 28401NDS01_10

Deviation: the electrical performance inspection and function confirmation of the EUT is done only at Room Temperature agreed with customer.

Applicable standards: IEC 60068-2-60 Ke – Method 4

Test Parameters:

EUT number	3
Total Test Duration (t_{test})	21 days
Test Temperature (T)	(25 ± 1) °C
Relative Humidity (RH_1)	(75 ± 3) % RH
DUT Test Position	Original mounting position
Operation/Monitoring Mode	1.2
Operating Classes	Class A'
Gravity Level	0
Composition of Test Gases	
Hydrogen Sulfide (H_2S)	(10 ± 5) ppb
Nitrogen Dioxide (NO_2)	(200 ± 20) ppb
Chlorine (Cl_2)	(10 ± 5) ppb
Sulfur Dioxide (SO_2)	(200 ± 20) ppb

(Gas concentration in ppb = parts per billion(1 in 10^{-9}) volume per volume (vol/vol) in air)

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Before exposure measure the contact resistance according to the description below.
B. Place the DUT in the test chamber and subject them to the mixed flowing gas environment given in the test parameters given above. Refer to IEC 60068-2-60, Method 4, Test Procedure 2.
C. Following to the exposure, measure the contact resistance again according to the description below.

Acceptance Criteria:

Conduct a visual inspection, electrical performance inspection and function confirmation of the EUT at Room Temperature .